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Photograph by Ben Knutson

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DISCOVERY

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THE PROGRESS OF SCIENCE

LYSENKO UNDER FIRE

The career of a scientist who jumps on the political band-waggon is not to be traced through scientific journals, and for this reason if one wants details about the advancement of Trofim Lysenko one is bound to turn to such papers as *Pravda.* A strong hint was recently given in *Pravda* that Lysenko no longer enjoys quite the same political favour and political protection from criticism that he used to be able to rely upon. It seems that one of his protégés, V. C. Dmitriev, submitted a doctoral thesis which the Institute of Genetics did not consider satisfactory and which it therefore rejected —which is something that could certainly not have happened six years ago when Lysenko had the direct support of the Central Committee of the Communist Party. At this stage Lysenko intervened, and the upshot was that Dmitriev was awarded his doctorate. *Pravda* of March 26 printed a letter by a non-party scientist, Prof. S. Stankov, stating that the thesis of Dmitriev was "unsound" and calling the award of a degree for it "a mockery of Soviet science".* According to *Pravda*, the Institute of Genetics has now reconsidered the matter and has stripped Dmitriev of his newly-granted degree. The incident speaks for itself and requires no comment.

There are moreover plenty of other signs that the tide has turned against Lysenko. *Scientific* criticisms of Lysenkoism have been mounting, and it is rather amusing to note that some of the British exponents of this mystical creed have come under fire in Russian scientific journals. Lysenko himself has even been accused of holding anti-Darwinist views.

* The essence of this thesis, according to Prof. Stankov, was the Lysenkoist idea that cultivated crops spontaneously generate their own weeds: as Prof. Stankov expressed it in his letter, rye is supposed to breed its own rust, oat breeds its own wild oats, and a sunflower crop breeds its own species of weeds. The letter in *Pravda*, which carried the heading "Concerning a Vicious Thesis", said that at his oral examination Dmitriev showed a weak knowledge of elementary biological laws, adding that "this is understandable since Dmitriev as a Candidate of economic science has not deeply concerned himself with biology".

Very vigorous attacks have been made on Lysenko's 'interspecific conversion' theory, according to which there is no fixity about species, so that it is possible for wheat to be changed into rye—a transformation which Lysenko himself claims to have achieved. This theory runs counter to all experience, of course, and if there was any real truth in it then it would make nonsense of all taxonomy, and of stratigraphy (in which geologists rely upon being able to identify particular strata by means of the specific fossils they contain). Experts in both these fields have challenged Lysenko to establish his case, but he has never been rash enough to attempt to do so.

Lysenko has come badly unstuck over one case of 'interspecific conversion'. This involved a birch tree, a branch of which carried modified leaves resembling those of an alder tree. Lysenko held that this was an example of interspecific conversion—in other words, the birch was changing into an alder. In parenthesis, it needs to be added that birch and alder belong to two entirely different genera of the family Betulaceae. The phenomenon was investigated by a commission of scientists, who reported that the modification of leaf shape was a common phenomenon: the change was due to a fungus disease common in birch and resulted from infection by the fungus *Exoascus betulinus.* (An abstract referring to this case can be found in *Plant Breeding Abstracts* for Jan. 1, 1954.)

We hardly need to point the moral to this story, for it is altogether too obvious. Lysenko's future has been reasonably clear for quite a long time, and this comment on Lysenko which appeared in DISCOVERY, Dec. 1951, is even more topical today than it was when first printed: "Political patronage is always fickle, and the scientist who builds his career on political influence can win only an ephemeral reputation either as a scientist or as a politician. The most successful scientists appear to be the ones who have least to do with the Communist Party". Vavilov, whose position Lysenko so disgracefully usurped, would be entitled to make a much more

caustic comment—were he still alive to witness the discomfiture of the once promising physiologist whom he so generously encouraged and befriended.

J. B. S. Haldane once wrote: "Some of his work may turn out to be fallacious; it will certainly have to be revised in detail. Nevertheless it is extremely interesting as an example of the kind of work on which a biologist embarks under the influence of Marxist ideas, and in a society where those ideas are dominant". These words were intended to apply to Vavilov, but curiously they seem rather more fitting for Lysenko. Under Vavilov genetics made wonderful progress in Russia, but that progress was halted when this science came into conflict with Marxist ideas. The ripples set up by the resultant controversy reached Britain, and we were forced to witness the conflict between genetics and Marxism as epitomised by the case of Haldane, a microcosmic struggle which formed the theme of John Langdon-Davies's brilliant book *Russia Puts the Clock Back* (1949). The controversy has been settled in Britain, mainly on scientific grounds though some of the factors which it involved were political factors and had to be dealt with appropriately. What has happened in Britain has certainly been noticed in Russia, and has given Russian scientists the courage of their scientific convictions. Until quite recently it was only men like Lysenko and his protégés who could call something with which they disagreed 'a mockery of Soviet science'. The tide has turned with a vengeance, and it is now Lysenko who must answer that charge.

Lysenko (*centre*) at the beginning of his career, photographed alongside Prof. S. C. Harland, the geneticist (*right*). Prof. Harland's opinion of Lysenko was expressed in DISCOVERY in 1949 when he wrote: "In 1933 I saw Lysenko in Odessa, catechised him for several hours and inspected his practical work. It was quite clear that Lysenko was blazingly ignorant of the elementary principles of both plant physiology and genetics. You simply couldn't talk to Lysenko—it was like discussing the differential calculus with a man who did not know his 12-times table."

Postscript. Since this note was originally written the Communist Party journal *Kommunist* has published a powerful criticism of "scientific monopolists" who attempt to carry on a one-man rule and stifle all opposing theories. It mentions specifically N. V. Turbin's views on Lysenko's "interspecific conversions" and criticises the Russian journals which afterwards published articles, "plastering him [Turbin] with the labels of Weismannist-Morganist, vulgariser of Marxism-Leninism and so forth and so forth". Turbin's letters of protest to these journals went unpublished, says *Kommunist*, which then comments that "those who choke off criticism in scientific work profoundly damage science and should receive a timely rebuff". The magazine expressed disapproval of persons who meet any kind of criticism by picking to pieces the critic, subjecting him to defamation and "excommunicating" him from Marxism.

THE COLOUR VISION OF BEES

Some of the most fascinating biological studies ever made have been concerned with the social insects, in particular the ants and the bees. A vigorous centre of bee research is the Bee Department of Rothamsted, and one of the research workers there has now published an excellent book—*The Behaviour and Social Life of Honeybees* by Ronald Ribbands (Bee Research Association, London, one guinea)—which provides a most compact and up-to-date account of the many investigations made in this field.

One aspect of this subject which has received much attention is the visual sense of bees, in particular their colour vision. The starting point for this work was the observations of naturalists who noticed how certain types of insects favour specific types of flowers. Close study of the phenomena of insect pollination led to the classification of flowers into various categories according to the types of insects which perform the pollination. Thus we get the flowers with exposed nectar—such as the umbellifers and the saxifrages—which are chiefly visited by short-tongued flies and beetles. At the other end of the scale are the highly specialised flowers whose nectar is out of reach of small insects with short tongues. Here we meet the Lepidoptera flowers (e.g. honeysuckle, Nottingham catchfly, night-scented stock) which attract butterflies or moths, and the Hymenoptera

flowers which attract bees. Some of these flowers are closed structures which only heavy insects can open and pollinate; the snapdragon and broom are examples. Other highly evolved flowers which can only be pollinated by certain specialised kinds of insects are the sage, violet, monkshood and orchids. In other flowers such as the columbine the nectar is concealed at the bottom of special spurs, and these plants can only be pollinated by insects with long tongues; to the same end the nectar may be protected by barriers of hairs or scales which exclude small flies.

If one considers the group of flowers pollinated by flies and the 'bee' flowers, one finds a striking difference in respect of colour. The 'fly' flowers are white or yellow (often a dirty tinge of yellow) or dull red or green. In the 'bee' flowers, blue and purple are the colours which predominate.

The evolutionary significance of flower colour is something which has interested many scientists, who have established that "the great advances in the evolution of insects and of brilliant flowers were contemporaneous". There is no doubt that the bees, for instance, evolved *pari passu* with the most specialised flowering plants. It is generally agreed that blue tints in flowers were late in evolving, and came on the scene after yellow and red. (Green and white are also *primitive* flower colours.)

About 1880 the question was posed, *Is blue a colour particularly attractive to bees?* Pollination studies suggested that bees showed a preference for blue flowers, but the early experimenters who studied bee behaviour were sceptical about this alleged choice. Thus we find this view being expressed about half a century ago: "it matters not one iota to a bee whether the flower is blue, red, pink, yellow, white or green: so long as there is honey, that is sufficient". These words were quoted with approval by the great Forel in his classic book *The Senses of Insects.* This extreme scepticism about the bee's ability to appreciate different colours went much further than any of the established facts justified, though it would have been perfectly legitimate at that time to ask whether it was the *brightness* of blue flowers rather than their blueness which attracted the bee's attention. This question was settled once and for all by von Frisch in the first of his classic experimental studies on honeybee behaviour. He prepared a series of fifteen shades of grey cards that formed a carefully graded series between black and white. These cards he arranged on a table along with a single blue or yellow card. All the cards were covered with a sheet of plate glass, and a small watch glass was placed over the centre of each card. The watch glass on the coloured card was supplied with sugar syrup, and the bees accustomed themselves to feeding there. At short intervals the cards were rearranged, but food was only supplied on the coloured card. Then clean empty watch glasses were supplied at all the cards, so that no food at all was available, but the bees still went unerringly to the coloured card, which they distinguished from all the shades of grey. Von Frisch found it impossible to

FIG. 1. The petals of the Columbine (*Aquilegia*) are drawn out into spurs, at the bottom of which the nectar is secreted. This adaptation secures pollination by long-tongued insects.

train the bees to select one shade of grey in preference to another, although the insects can quite definitely distinguish different degrees of brightness. (In one set of experiments bees were able to distinguish a difference in brightness of 23% between two surfaces; other experiments showed that they can differentiate between two light sources which differ in brightness by 14%.)

The next question to be answered was this: *Is the attractiveness of different coloured surfaces all due to ultraviolet light?* About 1920 it was effectively proved that bees are very sensitive to ultraviolet, and soon afterwards it was shown that they can be trained to go to the ultraviolet or another band of colour in a projected spectrum of colours.

Next the ultraviolet properties of flowers were tested. About 30% of conspicuous flowers proved to be distinctly ultraviolet—that is, they reflected ultraviolet light. Many white flowers, however, including *Convolvulus,* phlox and roses, were found to reflect little ultraviolet, in contrast to evening primroses and red poppies which reflect much ultraviolet.

About 1924 it was established, by von Frisch and by Kühn, that bees can discriminate between orange-yellow, blue-green, blue-violet and ultraviolet. Both these experimenters thought that the bees were quite unable to discriminate between different shades within

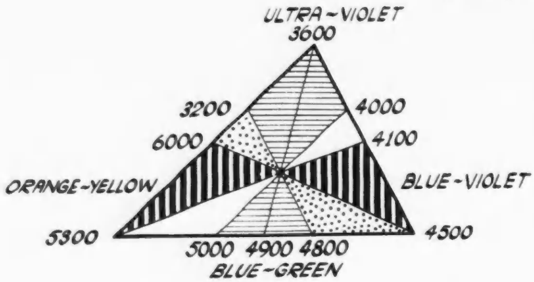

FIG. 2. The colour triangle for the honeybee.

one of these colour bands; thus within the orange-yellow band (5100–4800 Ångströms) the bees were reckoned to go indiscriminately to the orange, yellow and grass-green regions; again, bees which were accustomed to the blue band (4700–4000 Ångströms) seemed to be incapable of discriminating between the purplish-violet region and the blue region.

Later experiments by Kühn and Fraenkel revealed ability to discriminate between shades within a particular colour band. This was true of the orange-yellow band and of the blue-violet band.

A 'colour triangle' has been constructed which claims to represent the honeybee's colour vision (see Fig. 2). Assuming that this approximates to the truth, then the basis of colour vision in bees and humans seems to be similar—with the one big difference that the red-sensitive units of the human eye are replaced by ultra-violet-sensitive units in the bee's eye.

The preference of honeybees for particular flower colours is something which requires more investigation. The experiments of Müller and Lubbock (both of whom published their results in 1882) suggest a distinct preference for blue, but neither experimenter allowed for the bee's sensitivity to ultraviolet. Ribbands suggests that contrast with the background might affect their choice, since the greatest contrast to a grass-green background would be provided by a blue flower. This kind of strong colour contrast is also demonstrated by the so-called 'honey guides' of *Viola*, etc.; a very similar contrast (between yellow and blue) is found in the forget-me-not flower.

Readers who want an up-to-date book about bees cannot do better than read Mr. Ribbands's book. They will also be interested in von Frisch's *The Dancing Bees*, which has just been published by Methuen at 16 shillings. Also well worth consulting is the book by Dr. C. G. Butler of Rothamsted, *The Honeybee: An Introduction to her Sense-Physiology and Behaviour* (1949).

INDUSTRIAL RESEARCH AROUND MANCHESTER

There is an influential school of thought which blames all of Britain's economic difficulties upon the neglect of science by our industrialists. Exponents of this view express their belief that British industry lost its way sometime about the middle of the last century, after achieving a legendary Industrial Revolution in which science played the dominant role. Since that time fundamental discoveries and important inventions have not been developed quickly enough; generally our technology has languished, as compared with that of Germany and the U.S.A. According to this view, British science and British scientists are frustrated; far too many discoveries and inventions which originate in Britain find their way into the 'ice box'. (There is only one worse fate than this, we gather: that is for an idea to be exploited successfully in the U.S.A. The twist in the argument makes it possible to kill two birds—the British industrialists and the American industrialists—with the same stone.)

These assertions—and they are no more than assertions—were first heard over half a century ago. They date back to the closing decades of the nineteenth century, when the unique economic and technical supremacy which Britain enjoyed in the mid-Victorian era was beginning to be strongly challenged by Germany and the U.S.A. These assertions add up to a theory of British economic stagnation, a theory which we hasten to add has never been clearly established and which is now coming under heavy attack. It can be shown without difficulty that we have approached the training of technologists in a less organised way than many other countries, but there is a credit as well as a debit side to the balance sheet; Britain may be short of first-class technologists compared with the United States, but on the other hand the versatility of our best technologists is something for which the Americans have a high regard, judging from the tempting offers which U.S. firms make to British experts. It cannot be shown however that the economically depressed 1930's were a period of unmitigated industrial stagnation, nor can it be established that this was a period during which useful developments were wilfully suppressed. The truth is certainly much more complex than was once thought. It cannot be simply described in terms of money spent on research, nor in terms of monopoly, nor even in terms of educational practice. We do not yet know why some economies are more successful than others, and why our own has run into the doldrums—unless, of course, we care to be more dogmatic than a genuinely scientific attitude permits.

It is for these reasons that any investigation into the relations of science and industry is likely to be at once both important and disappointing, and the three years' work of the Manchester Joint Research Council culminating in the report which prompts this note* is no exception. As the report itself comments, the accumulation of facts, given a number of well-disposed informants responding to precise questions, is not a difficult matter. Saying what those facts mean is another kettle of fish.

This report confines itself to a limited area around Manchester, and to firms employing more than fifty

* *Industry and Science: A Study of their Relationship in the Greater Manchester Area* (Manchester University Press, 1954, 12*s*. 6*d*.)

workers and without country-wide ramifications. The main facts it reveals are as follows. Between 40% and 52% of a sample of these firms, employing about 84% of local manufacturing labour, employ at least one scientist or technologist, as broadly defined. Some of these are to be found as directors of business, and one in every nine science graduates employed has so far succeeded, without having family connexions, in establishing himself as a director of his firm. Rather less than half the firms investigated appeared to be understaffed with scientists, and about a third had no qualified staff at all. Research and development work of all kinds was carried out, and contacts with the universities (Manchester University in the main, but also Leeds), and with Research Associations, were more frequent than has often been supposed.

Are these findings a matter for congratulation? As a piece of patient and honest research in a difficult field, they certainly are, but what they mainly reveal is the limitations of this kind of approach. No one can easily say how many scientists ought to be employed in industry; no one can say clearly what they ought to be doing in firms of different types producing different kinds of products for differing markets. Only careful and objective investigation in conjunction with particular firms over a long period of time could reveal this, and only a progressive board of directors could make useful employment of science an established fact. So much the report admits. We have heard many times before of the importance of being 'science-minded', and this point is underlined by the report. But this report is not always so objective. It argues that there are many firms which, on account of the routine nature of their activities, have little need of scientific knowledge, and these appear to amount to about a third of those examined. Yet it also reveals a general need for a more scientific approach to the normal operations of existing plant and machinery. The two arguments go ill together. Can it be that the joint nature of the research, which is a common venture of university and industry, has led the reporters to let industry down too lightly? The report is right to argue that the greatest amount of progress may not be achieved by petulant criticism of industry. It is also right in suggesting that ceaseless contact between businessmen and scientists in all organisations is an effective way of getting things done. But is it right in pulling its punches at points where it reveals hard hitting is justified? Is the businessman's skin so shallow that he cannot be subjected to friendly but adverse opinions?

TRANSISTORS

During recent years, few developments in the electrical sciences have caused such widespread interest as the transistor. This new circuit element was first announced by J. Bardeen and W. H. Brattain of the Bell Telephone Laboratories, New York, in 1948 (*see* DISCOVERY, September 1948, pp. 268–9). It consists essentially of a crystal of germanium to which three electrodes are attached. Although all commercial transistors have so far used germanium as the semi-conductor, extensive research is proceeding to find the potentialities of other such materials, particularly silicon. Transistors are descendants of the crystal detectors used in the early days of radio, but they differ from these in that they can be made to perform many of the functions of multi-electrode valves. They can, for example, be used as amplifiers, signal generators and oscillators, and they have the great advantage of requiring no heater current. Moreover, they are extremely small and compact and have been known to give useful lives of 70,000 hours and more.

These features of the transistor have naturally attracted the attention of electronic engineers all over the world, and an enormous literature has grown up around their possible uses.* In spite of this, however, most of the applications of transistors are as yet still in an experimental stage. The principal commercial outlets for transistors have so far been in hearing aids, electronic computors and submarine cable relays, where small dimensions and low power consumption are at a premium. In such applications, it seems likely that in the future transistors will, to a large extent, take over the functions of the electronic valve. But numerous problems will have to be overcome before the use of these new circuit elements can be extended to other fields. One of the main difficulties is to mass-produce transistors with uniform characteristics. Before this problem could be tackled, a great deal of research had to be done in the whole field of semi-conductors. Coupled with this, numerous technological problems connected with actual manufacture have had to be solved. The success which has attended efforts in these directions may be judged from the fact that, in little more than five years, an extensive range of semi-conducting devices of various types and forms has been developed, which offer the circuit designer enormous possibilities. Probably the most important among these is the junction-type transistor which overcomes many of the limitations of the point-contact transistor, especially relating to noise, power efficiency, operating voltage and power handling capacity. Junction transistors, which were first introduced in the United States in 1951, are now available in commercial quantity in Britain, and they should do much to stimulate further experimentation in transistor circuitry. (This does not mean that point-contact transistors will automatically become obsolete, as there will undoubtedly remain such applications as computor or high-frequency applications where they have certain advantages.)

Before full advantage can be taken of the numerous interesting features offered by transistors, electronic engineers will have to become familiar with the basic principles of transistor circuitry. This presents considerable difficulty, since the characteristics and circuits of transistors differ in many respects from those of

* There has just come into existence a publication devoted exclusively to work on transistors. This is entitled *Transistor Research Bulletin*, and is edited by Michael C. Ellison, director of the National Scientific Laboratories solid-state physics department, from 2010 Massachusetts Avenue, N.W., Washington 6, D.C. This bi-monthly is published on a subscription basis.

valves. This is brought out very clearly in an important new American book that has just become available in Britain.* Written by recognised authorities, this book provides, for the first time, an integrated treatment of transistor characteristics, circuits and theory. It is an attempt to bring together the essentials of existing research material on transistors and other semi-conducting devices, and there is no doubt that it will provide a firm background for circuit designers entering this rapidly-progressing field.

SYNTHETIC RUBBER PRODUCTION IN BRITAIN

Two years ago (PROGRESS OF SCIENCE, March 1952) we examined the chances for production of synthetic rubber in Britain. The predictions we then made have been largely confirmed by recent announcements that three industrial organisations are planning new developments. The firms involved are I.C.I., Dunlop and Monsanto. The scale of production envisaged is not great enough for this synthetic rubber to be a serious competitor with natural rubber in this country. At present our consumption of natural rubber is around 220,000 tons a year. The estimate of 10,000 tons a year from I.C.I. and 2000 tons a year from each of the other producers does not constitute a major inroad by synthetic rubber; in fact this output will little more than double the figure of 6000 tons which is consumed here at present. On the other hand it does replace a dollar import, and allows for an expansion of consumption without using up dollars.

What these new ventures will mean in practice is new applications for specialised products. The I.C.I. output will consist largely of Perbunan, an interpolymer of butadiene and acrylonitrile. This has the property of resisting attack by oils. (Ordinary rubber tyres for example rapidly deteriorate if allowed to stand in pools of lubricating oil.) Its main outlet will be in replacing leather for shoe-soles. Other uses will be found in the form of rubber latex, which will go into the manufacture of emulsion paints whose production has grown rapidly with the demand from the home-decorator for something he can rapidly apply to walls with a roller. Other types of rubber will be butadiene-styrene copolymers, of which the most familiar is the American type GR-S. The butadiene will be made from the oil cracker gases at Wilton, where acrylonitrile is another product arising from the manufacture of 'Perspex'. Styrene is apparently a new product for I.C.I. and it is not yet clear whether this will be made from benzene and Wilton ethylene, or shipped in.

It is clear that I.C.I. have a strong position in the synthetic rubber field because of their control over the intermediate chemicals involved in these syntheses. Their statement of plans anticipated that of the Dunlop Rubber Co.'s scheme to make 2000 tons a year at a plant cost of £500,000. It appears that the trial balloon sent up by Sir Clive Ballieu two years ago has been shot down in flames. He then declared it was timely for "the Government, the chemical engineering industry and the consuming industry to consider afresh what appropriate action can be taken to establish the manufacture of synthetic rubber in this country". In the context of his remarks at that time there loomed the Malayan emergency and the possibility of losing our natural rubber supplies. There was also the American picture of synthetic rubber dominating the market. Circumstances have changed considerably since 1952. The Malayan situation is now in hand, and American production of synthetic rubber has been cut down to an annual rate of 450,000 tons as against 800,000 tons last year.

The 2000 tons from the new Dunlop plant represent little more than pilot quantities, and do not indicate that this factory will produce butadiene and styrene. These materials will probably come from the Grangemouth plant in which Anglo-Iranian, Distillers and Monsanto are concerned. This plant will definitely supply the primary materials for the Monsanto project, and new styrene capacity is being added at Grangemouth to deal with this as well as the increased demand for polystyrene.

The new synthetic rubbers are welcome because they will be of adequate size to allow the techniques of production to be perfected. The polymerisation of these chemicals has been a harder task to carry out in some ways than the big leaps in the dark which produced immense styrene and butadiene plants in the U.S. 'Cold' polymerisation (at 41°F) and the 'oil-extending' of synthetic rubbers have yet to be worked out on a big scale in this country. The establishment of the plants may also encourage more experimental work on modifying the properties of natural rubber by co-polymerisation with some of these unsaturated monomers. If something on these lines came off, it would give a much-needed stimulus to natural rubber production.

ELECTROGYRO LOCOMOTIVES AND BUSES

Recently Mr. E. H. Browne, Director-General of Production to the National Coal Board, announced that the N.C.B. were going to undertake experiments with an 'electrogyro' shunting locomotive. This locomotive, which will be used for shunting work on the surface during the experimental period, will have a special system for storing energy for traction purposes which depends on a large flywheel in the centre of which a squirrel cage electric motor is mounted. The framework of the new N.C.B. locomotive is being built in this country, but the Oerlikon electrogyro engine is being imported from Switzerland. If this shunting engine proves successful, the possibility of building mine locomotives of similar design for use in transporting coal from the coal face to the shaft bottom will be considered.

The Oerlikon Engineering Co., who built the first electrogyro locomotive for use in their own shunting yards at Zurich in 1947, are already building mining locomotives of this type for a number of countries, including South Africa. They have also built a number of electrogyro passenger buses, two of which went on

* *Principles of Transistor Circuits.* Edited by Richard F. Shea; New York, John Wiley; London, Chapman & Hall; 535 pp., 88*s*.

FIG. 3. One of the Swiss 'gyrobuses'.

the local bus service from Yverdon, near Zurich, in Nov. 1950. These buses which are now in regular use have no storage batteries, need no special type of electrical power supply, and are not tied to overhead wires or fixed rails. They take on their supply of electricity at the normal passenger collection points by means of three contact horns which draw the current required from the ordinary electricity supply.

The secret of their operation lies in the large flywheel 1·6 metres in diameter and weighing 1500 kilograms which is mounted horizontally between the front and rear axles. This flywheel which is enclosed in a hydrogen-filled casing has a squirrel cage electric motor built on to its centre shaft.

When electric current is drawn in through the contact horns, this motor drives the flywheel, accelerating it up to 3000 revolutions per minute. If, however, the motor is switched off and excited with condensers, it becomes a generator and can then transform the kinetic energy which is normally lost when a vehicle stops and its flywheel is braked. Indeed, in the electrogyro bus, some of the braking energy itself can be utilised to accelerate the flywheel if electro-magnetic brakes are fitted.

These buses can travel about six kilometres between recharging points, but in practice they rarely travel more than a mile between stops (and recharging points). While the time needed to recharge the flywheel, which is already accelerated to 1500 revolutions per minute or more, is small, it may take up to 20 minutes to fully charge it from 0 r.p.m. up to 3000 r.p.m. For this reason the flywheel is kept running throughout the operating period of each day (and in some cases at night also) at a minimum speed of 1500 r.p.m. Its operating range lies between 1500 and 3000 r.p.m., and the acceleration of the flywheel from the lower speed to the higher speed takes a maximum time of three minutes. Since the amount of energy used up between bus stops is rarely enough to slow the flywheel to 1500 r.p.m., the actual recharging time at each stop is rarely more than a minute. The first of these gyrobuses had 30 seats and standing room for 20 passengers. It could travel at speeds up to 50 kilometres per hour, the speed being changed by means of pole-charging on the motor and generator. The vehicles have proved themselves exceptionally useful for short-range travel in both towns and mountainous country, and the weight and movement of the flywheel is said to give the buses exceptional stability and road-holding capacity.

XEROGRAPHY AND ITS RADIOGRAPHIC APPLICATIONS

W. D. OLIPHANT
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About a year ago I gave a description of xerography in the photographic or *optical* field (DISCOVERY, June 1953, pp. 175–9), and I then hinted that its application to X-ray photography, seemed to be well worth exploring. In the past year, work has been carried out in the laboratory and in the industrial and medical fields, but in this article I propose to consider only the medical application.

Before touching upon medical matters, perhaps I should say a few words about this new method of photographic reproduction. Xerography, unlike ordinary photography, does not require wet chemical processing: it depends on phenomena associated with electric charges, and that being so, dry conditions are essential. It is for this reason that the Greek word *xeros* (meaning *dry*) has been brought into the technical vocabulary to give us the word *xerography*. So, when we are dealing specifically with the X-ray application, we use the word *xeroradiography*.

The active material in xeroradiography (as in xerography) is amorphous selenium. It is deposited in the form of a thin film of about 1–2 thousandths of an inch in thickness on a metal conductive backing plate. In the dark, this film is an exceptionally good electrical insulator—in other words, it will not allow electric charges to move either across the surface or through the film itself. The film is made sensitive to radiation by charging it up just as one charges up a condenser in a radio set. The 'charging-up' is carried out by exposing the surface of the film (in the dark) to the electrical discharge from a point electrode which is maintained at anything from 6 to 15 thousand volts. During this sensitisation process, charges are uniformly spread over the surface of the film: the time needed is from 5 to 15 seconds, depending on the thickness of the selenium film used—the thicker the film, the shorter the time necessary. The degree of contrast that is obtained in the final picture is found to be dependent on the charge level reached during sensitisation. These charges will only leak through the film if it is now exposed either to light or to X-rays, and the amount of leakage in either case depends on both time and intensity of radiation.

After a xeroradiographic plate has been exposed, we are left with a latent image that is an invisible charge pattern. This pattern is a record of the intensity of the X-rays that have fallen on the plate. To make this image visible, the plate (still kept in the dark) is placed over a specially designed developer box. A cloud of finely divided and electrically charged powder particles is generated inside the box. These particles are allowed to come into contact with the surface of the plate. They are attracted to the surface and adhere to it according to the charges left in the latent image. The X-ray picture (or radiograph as it is called) is now available for examination. The time necessary for development is generally of the order of 30 seconds so that for the vast majority of medical exposures, a radiograph can be obtained in well under a minute. As both the sensitising and developing boxes are light-tight, it is not necessary to use a dark room. In fact, the entire equipment can be built into quite a small trolley so that it can be used at the bedside in a ward or alongside the table in an operating theatre. The only additional equipment, I need hardly add, is the availability of a portable X-ray machine.

Let me now describe a typical orthopaedic operation involving the use of xeroradiography as an operative control. Imagine that the patient is a child aged about twelve years: as the result of an attack of poliomyelitis in early childhood, he has a discrepancy in length between the two legs amounting to 2½ inches. It is possible to slow up the rate of linear growth of the normal leg, and so allow the affected one to catch up by the time growth normally ceases. This entails an operation at the site of the knee joint, in which stainless steel staples are inserted to bridge what is known as the epiphyseal plate or area of active growth. To arrest linear growth at the knee it is necessary to insert twelve such staples, each of which must be positioned precisely, and this requires X-ray control.

A RADIOGRAPH WITHIN A MINUTE

During the preliminaries to the actual operation the xeroradiographer sensitises a number of plates on the trolley which is parked in the theatre. These plates are kept in special light-tight containers known as cassettes: they are kept closed during the whole proceedings except when a plate is being sensitised or developed. The surgeon, having exposed the edge of the epiphyseal plate, partly inserts the first staple in the estimated position and immediately requires a check X-ray picture. The cassette, which houses the selenium plate, is wrapped in a sterile container and placed close to the knee joint. With the X-ray tube suitably positioned, an exposure is made and inside a minute the surgeon is looking at the result. Any necessary correction of alignment or position is then completed and further staples are inserted. Several check xeroradiographs are required before all the staples are accurately placed. The saving of operation time can well be imagined.

Before xeroradiography was introduced into operational control, X-ray photographic films had to be used.

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FIG. 1. Xeroradiograph of an ankle, showing fracture dislocation of ankle joint.

FIG. 2. Xeroradiograph of ankle in plaster. In this case the medial malleolus of the shin bone is fractured. (The malleolus is the rounded lateral projection at the ankle end of the shin bone.)

and this meant that the radiographer had to send the film to a nearby dark room for development and fixation. Then, before the film was dry, it was brought back to the operating theatre so that the surgeon could have a look at the result. This involves a delay of anything up to about four minutes on an average, and of course there are as many films used up as there are exposures taken.

In the treatment of fractures it is important, for medico-legal purposes, to have a permanent record of the first and last radiographs in the series, and this can be done very conveniently with the help of a 35 mm. camera.

USE IN THE FRACTURE CLINIC

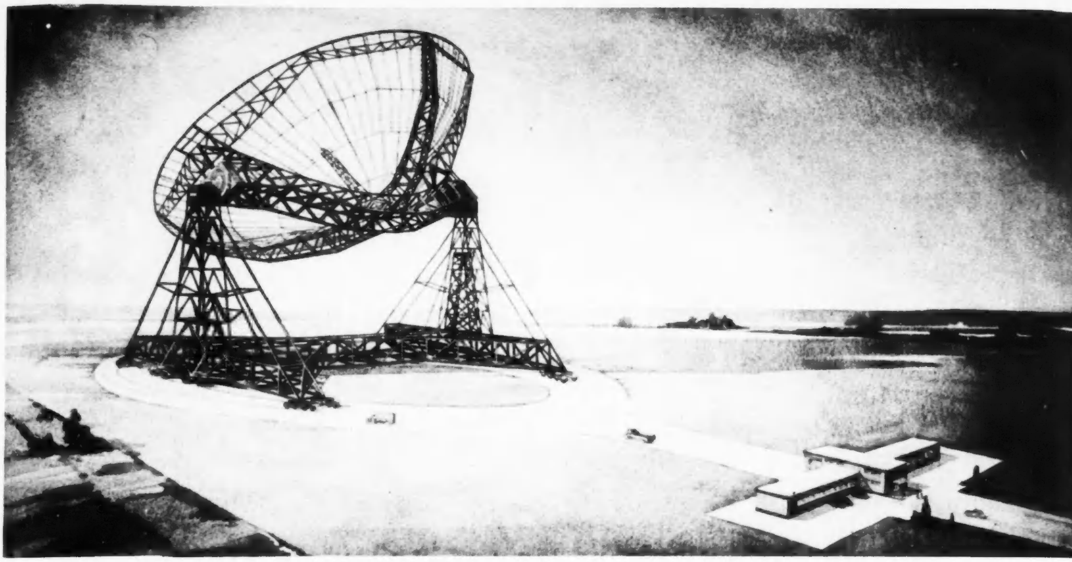
Finally, while the surgeon is suturing and bandaging, the xeroradiographer cleans the powder off the developed plates, for they can be used again—in fact, a plate can be used hundreds of times provided care is taken both in handling and cleaning. All is now ready for the next operation, and the only material expended during the first operation has been a tiny quantity of developer powder. What then are the potentialities of xeroradiography in the medical field in the light of present experience? So far, our investigations have been confined to the orthopaedic speciality where xeroradiography is well suited to surgical and clinical practice. Pictures of the skeleton can be produced with great speed. They show in considerable relief the cancellous structure of bone and such things as fracture lines and epiphyseal lines. In addition, a certain amount of soft tissue detail (such as fascial and muscular planes) is shown. It has been found that bone outlines are, in general, more clearly portrayed than with normal photographic film—this is a characteristic property of xeroradiographic plates involving controlled contrast. The rapidity with which a picture can be taken is a great advantage, as we have seen, during a surgical operation. But it is also of great value in an out-patient department. A patient can, for example, have a fracture correctly reduced while under an initial anaesthetic; there is no need to administer a second anaesthetic on subsequent days. Patients with suspected fractures can have their minds put at ease in a matter of minutes. In the smooth running of a fracture clinic, the state of a large number of fractures can be assessed in a very short time without the necessity of having to develop films by wet processing and viewing them in a wet condition. We have obtained some excellent pictures with limbs in plaster. In other words, xeroradiography is a great saving of time both to patient and doctor.

Next is the question of economy. As we have seen, xeroradiographic plates can be used over and over again. The cost of X-ray film is a very large item in the annual bill of the National Health Service and the amount of film used up merely for check or control purposes is very considerable and indeed is never referred to again. When a permanent record is needed there are two possible ways of getting it from a developed xeroradiographic plate. The powder may be transferred from the surface of the plate to suitably prepared paper. This paper may, for example, have a superficial coating of wax so that after transfer of powder a gentle heat will fix it into the wax to make it permanent. But a certain amount of detail is always lost by this method, and I think it is much better to use a 35 mm. camera for *photographing* the plates. In this way we get a permanent record in very compact form and the amount of storage space is kept to an absolute minimum. In fact, the piece of 35 mm. film can be mounted on a card which also contains the case history of the patient. So, when an examination is necessary, the piece of film can be placed in a projector and a full size image is available on a screen; alternatively, enlargements can be printed off for, say, publication or report purposes.

I would like to add a note of caution. While we have achieved some very useful results, there is a lot still to be done. Experience has shown that the effective speed of a xeroradiographic plate is comparable with that of a piece of unscreened film. From the point of view of safety of the patient, it is therefore impossible to produce an adequate picture of a deep joint or bone without an unduly long exposure. Such an exposure, carried out a number of times, would have an injurious effect, particularly on the skin.

SPEED AND CONTRAST

In order to cut down exposure time in film radiography, fluorescent screens are incorporated in the cassette. Not only is the film influenced by the X-rays but also by light which is produced in the fluorescent material. Such a method certainly increases the speed of the film, but, in order to maintain a high degree of resolution, the fluorescent screens *must* be placed in intimate contact with the back and front surfaces of the photographic film. It is unfortunate that we cannot use such a method in xeroradiography. The front surface of a xeroradiographic plate must not come into contact with any other materials, otherwise the desired charge distributions will be upset. We have not yet succeeded in achieving a comparable speeding up of a xeroradiographic plate but research is still going on in an attempt to solve the problem. When the problem is ultimately solved it will be possible to apply xeroradiography in other medical fields, for example, in abdominal and lung radiography. Experience in the industrial field, where long exposure times do not matter, has shown us that minute detail within a mass of material can be reproduced with much greater contrast than with ordinary photographic film. If this experience can be obtained in medical radiography then we are well on the road to success in abdominal and lung diagnostics, as well, of course, as in a better portrayal of fracture lines than is at present possible under limited exposure conditions.



THE NEW RADIO TELESCOPE AT JODRELL BANK

By **PROF. A. C. B. LOVELL**, *O.B.E., Ph.D., F.Inst.P.*

The origins and early investigations in radio astronomy were described in DISCOVERY just over three years ago, and here it will be assumed that the reader is acquainted with the main features of this new science which that article described.* At that time it was obvious to those engaged in this field of research that the outstanding need was for greater gain and resolving power in the radio telescopes. This meant the design and construction of larger instruments of both the interferometer and pencil beam types. It is satisfactory to record that through the foresight of the D.S.I.R. and the Nuffield Foundation both types have since been developed in Britain. In Cambridge, Ryle has already brought into use a large new interferometer, and at Jodrell Bank in Cheshire the construction of a giant telescope of the pencil beam type is well advanced. The present article is concerned with the scientific design of this latter instrument and its expected performance.

FUNDAMENTAL FEATURES OF RADIO TELESCOPES

The wavelengths used in radio-astronomical investigations are limited by ionospheric effects at the long-wave end to about 15 metres, and by atmospheric absorption at the short-wave end to a few millimetres. However, before this lower limit is attained the decrease in received power with decreasing wavelength makes the observations extremely difficult, and so far the amount of work which it has been possible to carry out even in the centimetre waveband has been very limited. It has therefore been found most convenient to construct radio telescopes around the half-wave dipole as the basic unit. The centre-fed half-wave dipole of Fig. 1 (*a*) has a natural resonant frequency corresponding to a wavelength of twice its length. The polar diagram for reception of this dipole is shown in Fig. 1 (*b*) and it can readily be shown that the power gain over an isotropic receiving element is 1·63. Clearly, owing to the lack of directivity and low gain, this element is not of great value as a receiver in radio astronomy.

There are three common methods of increasing the directivity and gain: by the use of arrays of dipoles; by arrays of Yagi aerials; or by paraboloidal aerial systems. Apart from the new type of helical system developed by Kraus at Ohio, all radio telescopes have been of one of these types. Dipole arrays and Yagi aerials are relatively easy to construct, but complete reconstruction is needed whenever the wavelength is changed. In the case of the paraboloid, a change of wavelength is achieved by simply changing the half-wave dipole at its focus. Hence there has been little question that for large steerable radio telescopes, required to work over a considerable waveband, the paraboloidal form has unique advantages.

THE PARABOLOID AS A RADIO TELESCOPE

The simplest form of parabolic aerial is a cylindrical paraboloid, rectangular through the focus, as in Fig. 2. It is fed by a half-wave dipole at the focus, and if d, q,

* DISCOVERY, January 1951, pp. 6–12. See also *Radio Astronomy*, by Lovell and Clegg (Frontiers of Science Series, Chapman & Hall, 1952).

are the length of the sides it can be shown that the beam width to the first zero in the two planes is $\frac{\lambda}{d}$ and $\frac{\lambda}{q}$ respectively. The received power is effectively concentrated in a solid angle $\frac{\lambda^2}{dq}$, and the power gain is $\frac{4\pi dq}{\lambda^2}$. The relative ease of mechanical construction tends to be outweighed by the difficulty of feeding a large cylindrical paraboloid. A primary feed is required for each half wavelength of its length. Hence changes of wavelength with a large instrument become somewhat difficult. Nevertheless this type of aerial has been put to considerable use in radio astronomy, and cylindrical paraboloids form the basic units in Ryle's large new interferometer at Cambridge.

A full paraboloid with circular aperture has a beam with circular symmetry provided the aperture is uniformly illuminated. It requires only a single primary feed at the focus, and the power gain is $\frac{4\pi A}{\lambda^2}$, where A is the area of the aperture. The beam width is about

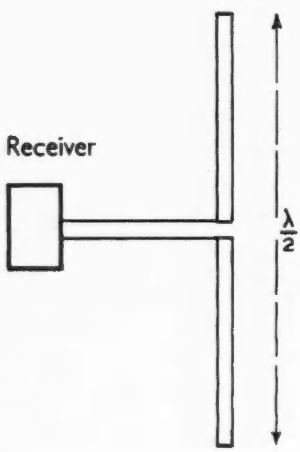


FIG. 1. (*a*) The half-wave dipole as a receiving element.

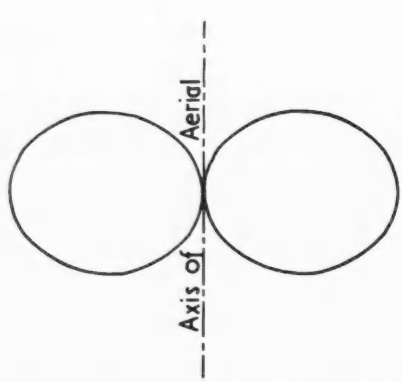


FIG. 1. (*b*) The polar diagram of the half-wave dipole. In the plane at right angles the diagram is circular about the axis.

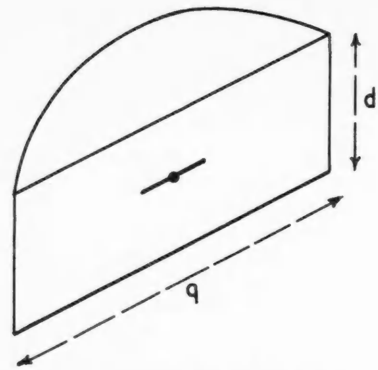


FIG. 2. Diagram of cylindrical paraboloid. The feed is generally a half-wave dipole at the focus.

20% wider than that from a uniformly illuminated rectangular aperture with sides the same as the diameter of the circular aperture, but the side lobes are considerably reduced.

The circular paraboloid is, perhaps, the most frequently used form of radio telescope. Its popularity is due to the fact that the feed arrangement is simple and hence the instrument can be readily adapted for use over a wide range of wavelengths. The paraboloid is also relatively easy to mount in a fully steerable mechanical system. An example of a radio telescope using a paraboloid with an aperture of 30 ft. is shown in Fig. 3. When the photograph was taken the telescope was in use on a wavelength of 21 centimetres. The power gain was 6350 over a half-wave dipole and the beam width 1·7° to half power.

THE LARGE TRANSIT TELESCOPE AT JODRELL BANK

The feasibility of using really large paraboloids as high definition radio telescopes has been demonstrated by the large transit instrument at Jodrell Bank. The construction of this instrument was commenced in 1946, and since 1947 it has been in regular use as a radio telescope for the study of the galactic and extra-galactic radio emissions. The aperture of the instrument is 218 ft., and an idea of its construction may be gained from the illustration in Fig. 4. The surface of the paraboloid is formed of conducting wires laid on a web of steel cables. The focus of this parabolic surface is 126 ft. above the ground, and the primary feed is carried at this point on a tower, the elevation of which can be controlled by an electric winch. By this means it is possible to give the beam a deflection of up to ± 15° from the vertical in the north-south plane. The departure of the surface from the true paraboloid is about 5 in., and this by itself would limit the lower wavelength to about 1 metre. The separation between the conducting wires is 8 in., and on a wavelength of 2 metres the leakage is 37%. It is this which actually

sets the lower working limit of the instrument at about 1·9 metres where the beam width is 2° to half power points and the power gain about 2000. The calculated power gain as a function of frequency is shown in Fig. 5. Allowance has been made for the inefficiency of the primary source, including losses due to back radiation, and the curve in full line shows the serious effect of the 8-in. spacing on the performance at short wavelengths.

The technique of using this telescope consists in setting the tilt of the mast to the required elevation (declination), and the coverage in right ascension is then given by the rotation of the earth. For each diurnal rotation the beam sweeps out a strip of sky 2° wide in declination and 24 hours in right ascension, and the power received by the aerial from this strip is recorded continuously on a moving chart.

Even though the use of the telescope is restricted to a small region of the sky, Hanbury Brown and his collaborators have obtained many important results in the study of the galactic and extra-galactic radio emissions. An example of the record of the radio source in Cygnus obtained with this telescope was given in Fig. 8 of the previous DISCOVERY article.

The early experience with this instrument demonstrated the practicability of large radio telescopes and left little doubt that a similar instrument, steerable to give coverage of the whole sky, would be of inestimable value, not only in the study of the galactic and extra-galactic emissions, but in all other branches of radio astronomy.

THE DESIGN OF THE LARGE STEERABLE RADIO TELESCOPE

During 1949 and 1950 the possibility of building a radio telescope as big as the transit instrument described above, but completely steerable, was discussed exhaustively. The question of decisive importance in any mechanical design is, of course, the size and the lower wavelength limit at which the radio telescope is to operate. It is well known that departures from the true parabolic shape up to $\lambda/8$ can be tolerated. For example, if the lower limit of wavelength is set at 1 metre then the tolerance in the shape of the bowl of the telescope can be as much as 5 in., but the shape has to be maintained in all positions of the bowl.

It is also necessary to decide the wind speeds under which it is desired to maintain any specified tolerances. The significance of this factor is obvious if reference is made to the official meteorological data for the British Isles. Even in the calmest central districts of the country the wind speed exceeds 15 m.p.h. for 35% of the time and exceeds 20 m.p.h. for 13% of the time. At the height of the bowl of the large radio telescope the wind speed under these conditions would exceed 20 m.p.h. for 35% of the time. Hence it would be unrealistic to specify a shape which could not be maintained at wind speeds of 20 m.p.h., otherwise the telescope would be out of action at its lower wavelength for 35% of time on account of wind conditions alone.

FIG. 3. A steerable paraboloid of 30-ft. aperture in use as a radio telescope at Jodrell Bank. The telescope was in use on a wavelength of 21 centimetres when this photograph was taken.

FIG. 4. The 218-ft. aperture fixed paraboloid in use as a transit radio telescope at Jodrell Bank. The primary feed at the focus is the dipole array carried on the 126-ft. mast. The beam can be displaced up to ±15° from the vertical by tilting the mast.

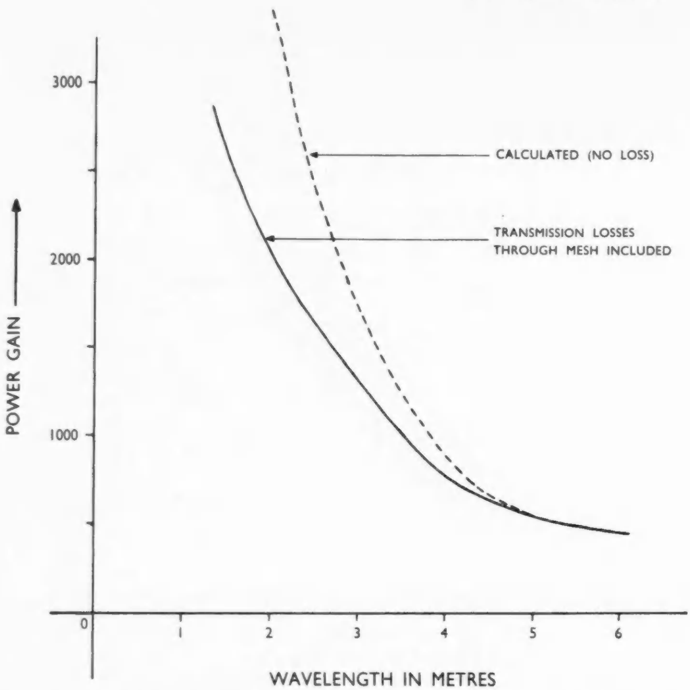


FIG. 5. The power gain of the 218-ft. transit radio telescope shown in FIG. 4, as a function of wavelength. The broken line is calculated on the assumption of no transmission loss through the mesh. The full line is the actual gain, including the losses through the 8-in. mesh.

The difficulties increase greatly as the wavelength is reduced, not only because of the increased accuracy required, but also because of the need for a closer mesh, which in turn leads to rapidly increasing wind forces on the bowl. As an example, the graph in Fig. 6 shows the power loss by transmission through a grid of various spacing at a wavelength of 1 metre. Even with a 2-in. spacing, 2·5% of the power is lost, and the loss increases rapidly as the spacing is increased.

It was therefore necessary to balance these various criteria against tonnage of steel, finance, aperture of the telescope, and the available information about the spectrum of the extra-terrestrial radio emissions.

(a) *The problem of the aperture*

In the case of the aperture the desire was naturally to make it as large as possible. On the other hand, because of the wind problems just mentioned, the cost increases rapidly with size.

Experience with the 218-ft. transit instrument had shown that the radio emissions from the Andromeda nebula and a few other extra-galactic nebulae were just on the limits of detection. It was therefore extremely important to achieve sufficient aperture to facilitate these extra-galactic studies. These, and other similar reasons, indicated that a 250-ft. aperture telescope would be a reasonable compromise. With the possibility of integration by virtue of following the nebulae with a steerable instrument of this size, there is every reason to anticipate that an entirely new avenue of extra-galactic exploration will be opened.

(b) *The lower wavelength limit*

From the discussion given above it will be evident that very strong arguments must be produced for designing a telescope of large size to operate on very short wavelengths. When the specification for the telescope was finally drawn up the position on the spectrum of the extra-terrestrial radio emissions was in some doubt. It was clear that the power from the radio sources was decreasing rapidly with wavelength. This, coupled with the worsening noise factors of receiving equipment at the lower wavelengths, had made it almost impossible to obtain reliable information about the spectrum at wavelengths less than about 1 metre. In fact, there was no justification for the gamble of designing the telescope to work primarily in the waveband below 1 metre and this was, in fact, taken as the shortest limit at which the telescope would normally be required to operate at full efficiency.

It was realised, of course, that the instrument would operate on wavelengths shorter than 1 metre with some sacrifice of efficiency, especially under calm conditions. For the specific study of the spectral line at 21 centimetres from the neutral hydrogen gas special arrangements have been made to provide the central portion of the bowl with a 2 × 1-in. mesh. This will enable the telescope to be used at a 100-ft. aperture on this wavelength.

(c) *The problem of the focal length*

So far no mention has been made of another crucial design parameter—that of the focal length. The large

transit telescope described above has a long focal length. This was determined almost entirely by constructional considerations. At Jodrell Bank in 1946 facilities were slender in the extreme, and those of us who built this telescope could only build a bowl as high as our ladders. The rather arbitrary result was a bowl 23 ft. 4 in. deep with the focus on a mast 126 ft. above the ground. One advantage of a long focus instrument is that it is easy to design the primary feed so that its polar diagram is uniform over the aperture plane. On the other hand the full power gain is difficult to achieve because of the 'overspill' radiation from the primary feed; that is, the aperture plane covers only a small part of the polar diagram of the feed. If the focal length is decreased this overspill is reduced, but the beam shape worsens because the polar diagram of the feed over the aperture loses its uniformity. It can be shown that in nearly all cases it is possible to balance these effects by suitable design of the primary feed so that the power gain can be made nearly independent of the focal length. Hence the choice of focal length can be governed by other considerations.

In the case of the new radio telescope the dominant consideration is that the power received in the overspill must be reduced to the minimum possible, otherwise the radiation from the intense sources in regions such as Cassiopeia and Cygnus will be recorded in the overspill when the telescope is directed to study the less intense regions of space. There is a further, purely mechanical, reason in favour of a short focus instrument. The size and complication of the primary feed increases with focal length if uniform illumination of the aperture is to be achieved. Hence, increases in focal length demand increases in length of the aerial tower carrying greater loads at the top. This is a difficult design problem with a long focus instrument since the tower has to be rigid enough to keep the aerial at the focus in all positions of the telescope. An examination of these various criteria left little doubt that a focal plane telescope was the correct choice. This, with a 250-ft. aperture, means a focal depth of 62·5 ft.

THE PREDICTED RADIO FREQUENCY PERFORMANCE

The predicted radio frequency performance of the telescope is summarised in Figs. 7 and 8. Fig. 7 shows the relation between the beam width and wavelength; the width is given to half power points and assumes that the primary feed is arranged to give a plano-sinusoidal distribution across the aperture. Fig. 8 shows the relation between power gain and wavelength. This takes account of the various loss factors such as those due to overspill of the primary feed, transmission loss through the mesh and departure of the surface from the true paraboloid as specified under conditions of no wind. It will be seen that at the normal minimum working wavelength of 1 metre the beam width will be a little under $\pm \frac{1}{2}°$ and the power gain about 16,000. With the central portion used on 21 centimetres the beam width will be $\pm$ 12 minutes to half power. The power gain at this wavelength will be about 100,000.

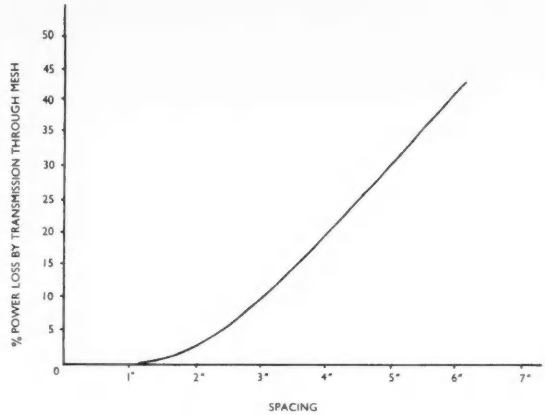


FIG. 6. The effect of spacing of the mesh on the transmission loss at a wavelength of 1 metre.

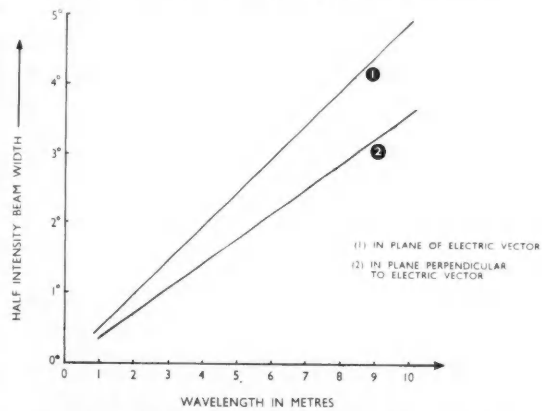


FIG. 7. The calculated relation between beam width and wavelength for the 250-ft. steerable radio telescope.

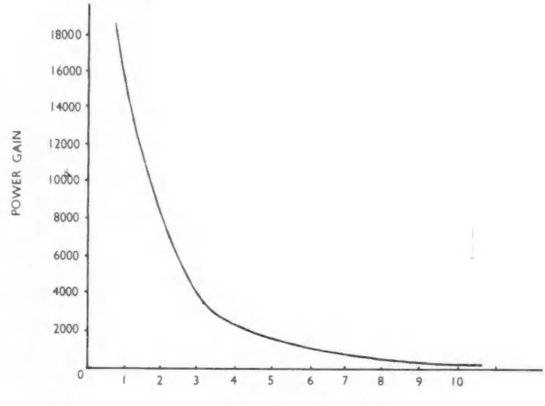
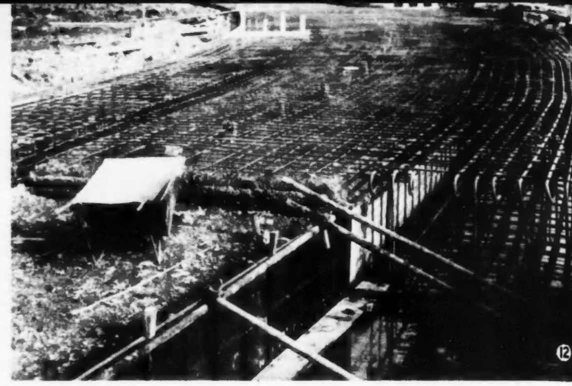


FIG. 8. Estimated power gain of the 250-ft. steerable radio telescope plotted as function of wavelength.



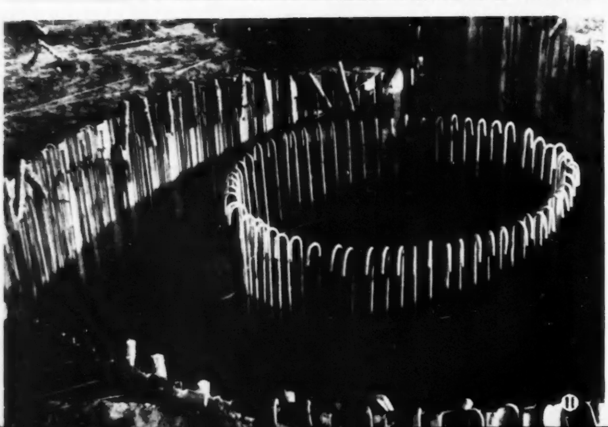


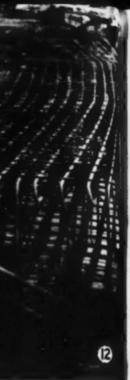
FIG. 9. Model of the steerable radio telescope. The 2-in. square mesh which will form the reflecting surface on the steel bowl is not visible.

FIG. 10. The site for the radio telescope in October 1952. This photograph shows the early stages of the deep piling operations.

FIG. 11. The reinforcing in the central thrust block of the radio telescope photographed in October 1952. This central pivot is not shown in the artist's drawing on p. 185, but can be seen in the model (FIG. 9).

FIG. 12. A portion of the ring beam of the radio telescope under construction in February 1953. This supports the railway track shown in Figures 13 and 14.

FIGS. 13 and 14. The laying of the 17-ft. gauge double railway track. January 1954.



THE ENGINEERING DESIGN

In the early days of exploring the engineering possibilities of building and controlling accurately the kind of instrument discussed above, a great deal of scepticism and discouragement was encountered. Eventually discussions took place with Mr. H. C. Husband of Sheffield, and by virtue of his great personal interest in the project and the skill of his staff, a feasible engineering structure was quickly evolved. Early in 1951 designs had been completed, but for nearly a year it seemed that the steel and financial crisis might cause the project to be abandoned. Finally, in the spring of 1952, the Nuffield Foundation and the D.S.I.R. announced their willingness to share the cost of the enterprise.

The artist's drawing reproduced on p. 185 shows the telescope as it is expected to appear when completed. The main paraboloidal bowl is carried on the steel towers at a height of about 170 ft. above the ground. Motion in elevation will be achieved by 100 h.p. electric motors, situated in the laboratories at the top of these towers, and driving through 27-ft. racks from the battleship *Royal Sovereign*. The towers are each carried on six bogies, the inner two of which are driven, the outer ones serving as wind carriages. These run on the 17-ft. gauge double railway track, again driven by 100 h.p. electric motors. The instrument moves about a large central pivot not shown on the drawing. The railway track, which has a diameter of 350 ft., is supported on very deep foundations and it has been necessary to sink reinforced concrete piles which extend from 45 to 90 ft. underground. Over 5000 tons of steel and concrete have been used in these foundations and the central thrust block. The total weight of the steel superstructure will be about 1200 tons, of which 500 tons is concentrated in the bowl itself and the back girder.

By mid-March 1954, all the foundation work was complete with the railway track in position. The preparation of the superstructure and the various other engineering items such as the central pivot and the bogies had also reached an advanced state in various engineering works throughout the country. Although it is difficult to forecast on such a complex structure, it seems reasonable to anticipate that the main steelwork will be erected in 1954 and that it may be possible to carry out preliminary tests before the end of 1955. The accompanying illustrations (Figs. 10 to 14) show various stages of the construction.

It will be obvious that the problem of controlling this telescope has caused much concern. Firstly, it is necessary to be able to direct this huge instrument to within 10 minutes of arc to any specified position in the sky, and then to give it a sidereal motion to maintain this direction. Secondly, it is necessary to be able to control the motions so that the telescope can be quickly placed in a safe position (bowl inverted) as a pure safety measure in conditions of extreme wind, or snow and ice. This second condition has determined the ultimate power reserves of the driving system (100 h.p. each in elevation and azimuth). Under conditions of normal use with the instrument in sidereal motion, the problem is not one of power, but of obtaining a steady motion within very narrow angular limits. The final decision was in favour of the metadyne type of control. The complex electronic controls necessary to convert the altazimuth motion to celestial co-ordinates have been designed by Dr. J. G. Davies of Jodrell Bank. These will be incorporated in a building which is connected with the central thrust block by an underground tunnel.

THE USE OF THE RADIO TELESCOPE

Even in an age which has become used to cyclotrons and synchrotrons, it cannot be denied that this radio telescope represents an expensive instrument—and a considerable engineering enterprise—for the purpose of fundamental research. It has already been the major preoccupation of a group of scientists for five years and is likely to remain so for at least another two years, even before it comes into operation as a scientific instrument. In spite of this it can be said without hesitation that all who are acquainted with the potentialities of this telescope become increasingly convinced that its completion will give Great Britain an instrument with unparalleled scope for the investigation of the universe. It seems likely that the primary concern of this radio telescope for some time will be the investigation of the galactic and extra-galactic radio emissions, including the preparation of a radio map of the northern sky. In co-operation with the results of the interferometric group in Cambridge, it is not unrealistic to expect that the paradox of the existence of these strong sources of radio emissions, in regions of space devoid of bright visual objects, may be resolved. The investigation of the solar emissions and of the whole field of solar terrestrial relationships fall within the programme of the telescope. When used as a transmitter the telescope will extend our knowledge of meteor astronomy, of the physics of the high atmosphere and of the aurora borealis. Finally it is possible to look forward to the time when the present transmissions to the moon will be extended to the planets.

In striving for ever-increased gain and resolving power through the medium of large interferometric and pencil beam radio telescopes, the radio astronomers are following the precepts and practice of the astronomers. The main advances in astronomy have emerged directly from the construction of telescopes of ever-increasing size, culminating in the 200-in. on Mt. Palomar. Increase of aperture gives more resolving power and more light-gathering power, thereby enabling more distant regions of the universe to be explored. The analogy in radio astronomy is very close, but since the wavelengths are a million times longer than light the radio telescopes have to be very much larger than their optical counterparts. As a compensating advantage the radio studies are uninfluenced by climatic conditions and hence Britain can proceed with confidence in this new field of astronomy.

THE DISORDERS OF ADAPTATION

J. R. F. E. JENKINS
M.R.C.S., L.R.C.P., L.M.S.S.A., D.P.M.

For more than a hundred years the study and treatment of disease has been regarded generally as resting upon a relatively simple basis of cause and effect; increasingly the cause of a particular disease came to be regarded as due to specific pathological agents, such as germs, chemical or physical factors acting on the body from without, or a disturbance of the internal production of hormones.

Such has been the progress made in the many sciences which now impinge on and contribute to the ever-expanding realm of medicine that this simple notion of cause and effect is no longer adequate.

To appreciate the importance of this changed attitude it is necessary to have some notion of what is called the *General Adaptation Syndrome* and to know something about the work which led up to the concept of *disorders of adaptation.*

In 1935 a young research worker, Dr. Hans Selye of Montreal, was investigating the sexual cycle in animals. He noticed that any form of stress—such as excessive heat or cold, or injury of any kind—not only upset this cycle but *also caused the animal to fall ill in a general kind of way.* Eventually Dr. Selye decided that it might prove more profitable to direct his researches into the mechanism of 'being ill' than continue his researches into the sexual cycle.

Dr. Selye soon found that all kinds of stress (such as excessive cold or heat, X-rays, injury, haemorrhage, pain, forced muscular exercise, intense light or noise, the injection of drugs or infection by germs) produced a similar general effect. The imposition of such stresses led to a three-fold response:

1. The Alarm Reaction.
2. The Stage of Resistance.
3. The Stage of Exhaustion.

These three generalised reactions which are likely to appear successively in response to the continued action of some noxious or damaging agent Dr. Selye called *The General Adaptation Syndrome.**

The Alarm Reaction, as its name suggests, constitutes a call to arms of the body's defensive mechanisms. It is characterised by an overall increase of white blood corpuscles, liberation of antibodies, enlargement of the cortex of the adrenal glands, a fall in blood pressure, etc. This is the state of 'just being sick'.

If the animal survived the initial shock of the damage for some hours or days, it tended to recover, and many of the changes which characterised the Alarm Reaction were reverse; this is the *Stage of Resistance.*

On the other hand if the stress was permitted to continue undiminished and proved too strong for the animal's defensive mechanisms, the general bodily changes again reverted to a state of shock, similar to the first phase of the Alarm Reaction and the animal died of *exhaustion.* (Similar changes are of course observed in human beings in response to comparable stress.)

These reactions were obviously very important and Dr. Selye proceeded to study them in greater detail. It was next found that removal of the cortex of the adrenal glands prevented most of the characteristic changes of the Alarm Reaction from occurring. It did more than that; it rendered the animal almost completely unable to resist and protect itself against anything more than the most trivial of stresses, e.g. trifling excesses of heat and cold, etc.

The next question—"what agent or mechanism activated the adrenal cortex?"—took a longer time to answer. The cutting of the nerves that were thought to activate the glands proved to have no effect.

In 1937 it was well known that the pituitary—the small gland situated at and connected with the base of the brain—was the master gland controlling the functions of the ovaries and so the sexual cycle in the female mammal. Any stress that called forth the Alarm Reaction (this includes worry, in the human subject) was able to upset this cycle by first interfering with the liberation of hormones by the pituitary gland. Dr. Selye removed this gland in rats and found that not only did the alarm reaction fail to occur in response to stress, but that the cortex of the adrenal glands degenerated as well.

The next step was to isolate the hormones which these two glands poured into the bloodstream, the one or more hormones from the pituitary which must activate the adrenal cortex (those already known from the pituitary which controlled the ovaries had no effect on the adrenal glands), and the several hormones from the adrenal cortex which act upon the body as a whole in response to stress. The latter hormones apparently serve to protect the animal as far as possible from fatal damage and mobilise its powers of resistance against injury and disease.

THE ADRENAL CORTICOIDS

All these hormones were isolated in pure form between 1935 and 1943, but it was only when such hormones began to be produced in adequate quantities for research purposes that unexpected results were found to occur.

It soon became evident from animal experiments that the adrenal cortex produced at least two distinct hormones, or perhaps two groups of hormones, which were responsible for the reactions of the body to stress. These hormones are collectively known as *adrenal corticoids.* One of them was evidently responsible for recovery from the fall in blood pressure and the disturbance of salt balance during the initial stage of shock. The other

* Syndrome = a group of symptoms and signs resulting from a disorder.

adrenal corticoid controlled the changes affecting the lymphatic tissues and the white blood cells and was also responsible for the restoration of the sugar level in the blood. (Without an adequate supply of blood sugar no cell in the body can work efficiently.) The first group of adrenal hormones are called *mineral corticoids*, and the second group are termed *gluco-corticoids*.

The mineral corticoid called DCA was the first which became available for experimental work. In the course of researches designed to reveal the particular effects due to DCA, surprising results were obtained when rats received overdoses of this substance. The animals soon showed one or all of the following changes. The blood pressure rose, and the arteries became thickened and fibrous (in other words, arteriosclerosis developed). The kidneys became fibrotic and diseased in a manner which was similar to the kidney condition of a person dying from high blood pressure and nephrosclerosis—as this kind of kidney disease is called. In the brains of rats so treated changes occurred resembling those in human patients dying of arteriosclerosis, which condition is a frequent cause of high blood pressure (hypertension).

Other and equally important changes were found in the rats' hearts and joints; here changes characteristic of acute rheumatism and rheumatoid arthritis occurred. The joints, particularly those of the feet, became inflamed and swollen, and if they were touched the rats would shriek with pain, like a human being in the throes of a rheumatic disorder whose inflamed joint is disturbed.

These findings by themselves proved little, but they offered more than a clue to the cause of these distressing diseases and indicated new avenues of research which might profitably be explored.

Critics at once raised the objection that these experiments were worthless as even if DCA was produced naturally by the adrenal glands—a fact then not proven—the doses required to cause these experimental diseases was quite in excess of the amounts the glands were likely to produce naturally within the body.

This particular objection was disposed of by the discovery of what is perhaps the keystone of Dr. Selye's more recent work, namely, the part which 'conditioning factors' play in the initiation and sustenance of disease processes in the body. Thus Selye soon found that an excessive proportion of salt in the rat's diet greatly reduced the amount of DCA required to produce the characteristic changes brought about by overdoses of this corticoid. Furthermore, damage to one kidney only (leaving the other kidney intact), as well as a high protein diet, further facilitated the disease process and caused its appearance under otherwise natural conditions and in the presence of quite normal amounts of natural mineral corticoids. These disease-assisting factors he called "conditioning factors".

One essential effect of DCA is greatly to increase the tendency of connective tissue—the tissue which holds together the essential elements of all organs and which largely forms the capsules of joints, etc.—to become inflamed. DCA does not directly cause the inflammation, but its presence, coupled with such factors as an

Dr. Hans Selye

excess of salt, conditions the connective tissue to such an extent that quite small stresses of all kinds are rendered capable of bringing on the reaction of inflammation. This reaction can, of course, be advantageous to the body, as for instance when it is evoked in early response to an infection which the body is thus enabled to eliminate rapidly and efficiently. But when this valuable reaction becomes unbalanced and exceeds the limits of normality then trouble can occur.

Further progress was made with the discovery that removal of both adrenal glands enabled the characteristic disease processes to be produced by smaller doses of DCA than were required with the glands intact. This suggested that the adrenals were also producing something which antagonised the mineral corticoids. These in fact proved to be the gluco-corticoids, one example of which is cortisone, which was isolated in 1943.

As cortisone became available for research purposes, it was possible to investigate the specific effects of the gluco-corticoids. In addition to and apart from the white blood-cell and lymphatic changes, and the effect on sugar metabolism already referred to, it was soon discovered that most of their actions were essentially antagonistic to those of the mineral corticoids. Animals suffering from artificially produced rheumatic disease (and other conditions due to DCA plus conditioning factors) rapidly recovered and became normal when given adequate doses of cortisone or ACTH.*

DCA and STH (the pituitary hormone which appears to act upon the adrenal glands causing the liberation into the blood of mineral corticoids) can be regarded as inflammatory hormones which increase the tendency of all connective tissue within the body to undergo inflammatory changes. In contrast, cortisone and other gluco-corticoids greatly reduce this inflammatory potential,

* ACTH is the pituitary hormone which stimulates the adrenal glands in the body to produce an increased amount of its own gluco-corticoids.

and under their influence inflammatory processes already in progress rapidly melt away. They do not affect the exciting cause of the inflammation (e.g. germs), but they influence the body's inflammatory reaction, and bring about a reduction of pain, swelling, redness and heat in the affected organ. It is as though the tissues of the body no longer bothered to react even to the invasion of dangerous germs.

Rheumatism and other disorders in the human subject had for some time been regarded as an exaggerated and abnormal response to small quantities of bacterial or other poisons. So cortisone and ACTH were tried on human subjects crippled with rheumatic diseases. The result was usually dramatic. In the case of swollen joints, the pain disappeared, the swelling subsided and the range of movement increased. It was soon found to be the rule that on discontinuing treatment the cases which had responded so well to cortisone soon relapsed.

Another and disastrous incidental result of the use of cortisone occurred in many cases of recovered tuberculosis. In the lung, tuberculous foci heal by the infected area becoming surrounded by a fibrous barrier; this fibrous tissue extends inwards turning the area into a fibrous nodule, and in this way any tubercle bacilli which are not destroyed are imprisoned and rendered harmless. (The process is reminiscent of the way an oyster neutralises a parasite by secreting a pearl around it.) From what has already been said about the effect of cortisone on inflammation, it is easy to appreciate that tuberculous germs imprisoned in this way might well be liberated by cortisone; with a reduction in the body's capacity to defend itself due to cortisone, a rapidly spreading and fatal infection might be a likely result. Experience shows this to be the case, and now when cortisone is used it is essential to exclude potentially dangerous T.B. lesions in the lungs. That cortisone could produce the reactivation of the T.B. process was seen by injecting two batches of mice with tubercle bacilli. To one batch of mice cortisone was also given, and these rapidly died of a spreading tuberculous disease. The mice which received no cortisone, but the bacilli alone, were able to hold the infection in check.

These few facts I have described and very many others connected with this research lead to a number of very important conclusions which are becoming more and more widely accepted by research workers and others connected with advances in the medical sciences.

As the story of the General Adaptation Syndrome becomes more fully told and knowledge of all bodily processes extends, it becomes increasingly obvious that there exists within the body in health a very nice balance between the various glands and other organs. The body is capable of a wide range of changes in response to stress of all kinds, without disease appearing, so long as the reactions of the individual component parts of the body remains balanced in its activity, the one with the others, in its response to the stressful situation or agent. When this balance is upset and the working of the whole is thrown out of gear, then and then only do these types of diseases appear.

This balance may be upset when excessive amounts of hormone are produced by one gland; the same effect may be produced when conditioning factors are present which bring about a quite abnormal response to normal amounts of hormone. Once the balance is upset by conditioning factors, then the response to normal degrees of stress becomes abnormal, and the resultant disease process seems often to be self-perpetuating, continuing long after the stressful agent or conditioning factors have ceased to operate. This kind of phenomenon has to be considered in the case of high blood pressure, some forms of kidney disease and many rheumatic and skin disorders.

Thus we see that the old idea of searching for the disease-producing agent is no longer adequate. Instead it is necessary to understand the *pathogenic situation* which has developed and caused the patient to fall ill.

One more point of the greatest significance might be mentioned. The pituitary gland controls practically every other gland in the body as well as most bodily functions and growth. Although the pituitary gland is connected with the base of the brain, it appears to work largely by balancing its own secretions (hormones) against the products of the tissues and glands on which its hormones have acted, like the thermostat controlling an electric refrigerator or a hot-water system. When the temperature reaches a set level the electric current is cut off; as soon as the temperature varies sufficiently the current cuts in again to restore the system to the required temperature and so on. While the pituitary gland appears to work in an analogous manner, yet it is also greatly affected by nervous impulses which travel along nerve fibres which connect the pituitary gland to the brain. By these pathways, impulses resulting from worry upset the production of pituitary hormones which control the sexual cycle as well as other bodily functions. So we see that the old idea of the possibility of controlling almost all bodily activities through the mind is not so far-fetched after all, and is one which might be developed much as yogis and others have long claimed to be able to do.

READING LIST

The January 1954 issue of *The Practitioner* contained a valuable symposium on Stress. Dr. Hans Selye's article on "The Adaptation Syndrome in Clinical Medicine" ended with a good set of references, including the three Annual Reports on Stress (for 1951, 1952 and 1953). The other articles in this symposium were: "Stress and the Cardiovascular System," by Dr. C. J. Gavey, of Westminster Hospital; "Stress and the Gut," by Dr. F. Avery Jones, of Central Middlesex Hospital; "Stress and the Rheumatic Disorders," by Prof. Stanley J. Hartfall, of Leeds University; "Stress Disorders in Children," by Dr. Ronald MacKeith and Dr. Desmond O'Neill; "Stress as a Factor in Dermatology," by Dr. John T. Ingram, of Leeds General Infirmary; "A Psychiatrist Looks at Stress," by Prof. D. R. MacCalman, of Leeds University; "Stress and Sport," by Roger Bannister; "The Importance of Leisure," by Sir Heneage Ogilvie.

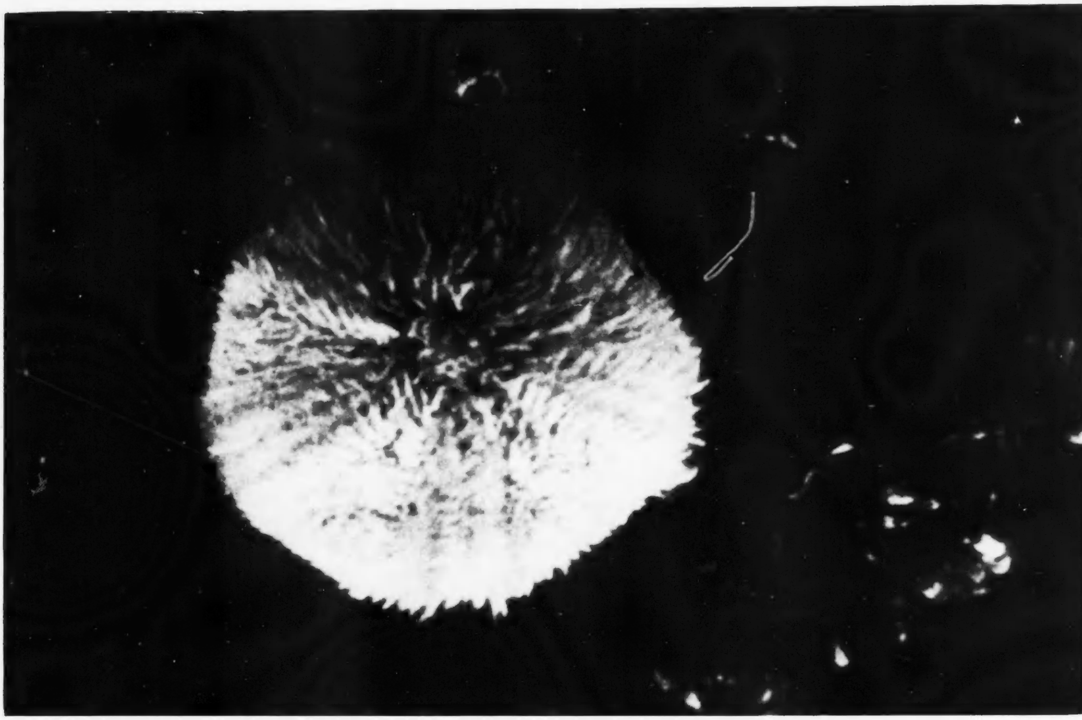


FIG. 1. *Echinus esculentus*. This TV picture was taken with a medium lens.

UNDERWATER TELEVISION PICTURES

H. BARNES
Ph.D., D.Sc.

An account has already been given (see DISCOVERY, June 1953) of the preliminary experiments on the application of underwater television to marine science being carried out at the Scottish Marine Biological Association's Laboratory at Millport on the Firth of Clyde. Since that account a considerable number of hours 'viewing' have been made and some of the results are illustrated in the accompanying photographs. The Clyde has been found very suitable for this development work since, except after heavy storms or winter rains, the clarity of the water is high; it will be remembered that clear water is essential for good pictures. As the clarity falls, due to suspended matter, picture quality deteriorates and in very dirty water the results are of little use to the research worker in marine biology.

It was emphasised in the previous article that the technique was likely to be most useful in ecological studies—that is studies of the intimate relations of animals to one another and to their environment. Various types of environment have been examined at depths ranging from a few feet to almost a hundred fathoms (600 ft.)—the deepest water in the Firth. In general the sea bed in deeper waters is mud and the epifauna, for which the technique is particularly suited to observe, is scarce. Most of the pictures which follow are taken between 20 and 200 ft., and show the typical epifauna of rough, gravelly or rocky bottoms in this area.

We may perhaps emphasise some of the advantages of this method. Compared with the older methods of net and grab it has the tremendous advantage that the animals can be seen *in situ*, and the detailed relations made out if necessary by observations over long periods. This possibility of long period viewing is a distinct advantage over remotely controlled underwater cameras: in the latter the biologist is, so to speak, shooting 'blind'; not until the film is developed does he know whether there is anything of interest in the field of view when the shots were taken. Compared with techniques employing divers with underwater cameras it has the advantage that viewing can be virtually continuous and that the biologist himself examines the scene, rather than receiving reports and a film from a professional diver.

Underwater television has its own limitations but the progress already made suggests it is an important addition to the techniques of marine biology and oceanography.

MARINE ANIMALS ON THE T

FIGS. 2, 3 and 4. A starfish (*Marthasterias* magnifications.

FIG. 2. In the bottom left-hand corner the (*Ophiocoma nigra*), each of which is abou
FIG. 3. This picture was obtained with th Brittle stars can be seen climbing over the change of lens gave this close-up of *Marth*

This series of pictures demonstrates one underwater television over 'blind' remot cameras.

FIG. 5. Close-up of *Ophiocoma nigra* and plate! This is the highest magnification wi the ground. The ophiuroids are about 5 in

FIG. 6. Gravelly ground with some stones tered about. A coelenterate, *Bolocera equ* small crab, *Munida bamffica*. Dead mollu

FIG. 7. *Luidia ciliaris* amongst ophiuroid voracious species and feeds on the ophiuro move over an ophiuroid ground leaving it stars.

FIG. 8. A collection of dead shells of *Glycy* patches, only a few square metres in ext over an area. This picture was taken in a r of Man. It was taken under poor working and with a four and a half knot tide—and satisfactory than in the others.

These illustrations were prepared from photogra these animals obtained on the screen of Dr. Ba

E ANIMALS ON THE TV SCREEN

A starfish (*Marthasterias glacialis*) at three different

ttom left-hand corner there is a mass of brittle stars *a*). each of which is about 5 inches across the arms. ture was obtained with the medium television lens. be seen climbing over the starfish. FIG. 4. A further ave this close-up of *Marthasterias*.

pictures demonstrates one of the great advantages of ision over 'blind' remotely controlled underwater

of *Ophiocoma nigra* and a barnacle-covered dinner highest magnification with the camera 6 feet from ophiuroids are about 5 inches across the arms.

ground with some stones. A few ophiuroids scat- oelenterate, *Bolocera eques*, in bottom centre and a *da bamffica*. Dead mollusc shells present.

iliaris amongst ophiuroids. The former is a very and feeds on the ophiuroids: this starfish seems to hiuroid ground leaving it practically clear of brittle

on of dead shells of *Glycymeris glycymeris*. Limited ew square metres in extent, were found scattered s picture was taken in a moderate depth off the Isle ken under poor working conditions—moderate seas nd a half knot tide—and the picture quality is less n the others.

ere prepared from photographic copies of the pictures of ained on the screen of Dr. Barnes's television apparatus

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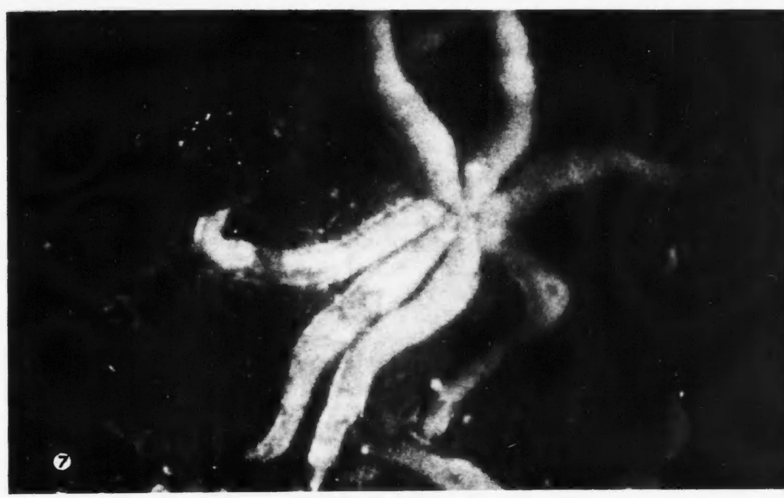

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THE SEAWEED FLY NUISANCE

HAROLD OLDROYD

M.A., F.R.E.S.

A year ago the name *Coelopa frigida* was known in this country only to a handful of specialists. Today it is better known to readers of the newspapers—for the time being—than *Pulex irritans* or *Cimex lectularius*, though to judge from a recent debate, confusion about the last two extends to high levels.

With amphibious warfare still fresh in our minds, it is understandable that the sudden appearance of great numbers of flies on the southern beaches should be seen as an entomological 'Operation Overlord' in reverse. Aircraft, flame-throwers and other mechanical equipment having been deployed against them, it required only the sudden appearance of airborne detachments in London to complete the illusion.

It is dangerous to prophesy, and I will not attempt to forecast where, or in what numbers, the seaweed flies will come into the news in 1954. My purpose in this article is to summarise what is known about them, and to attempt to see the outbreak of 1953 in its proper perspective.

THE NATURE OF THE BEAST

The family Coelopidae is a small one, belonging to a miscellaneous assortment of flies that is known as the Acalypterae. *Coelopa frigida* is one of five species, all of which are *endemic* in this country: i.e. they occur here naturally, and have done so from time immemorial. That is the first point that needs to be established. It is important to realise that we are concerned not with an invasion from without, but with an uprising from within.

These flies are littoral. Although they are closely related to other families represented inland, all the known Coelopidae breed among the heaps of uprooted seaweed that litter the beaches from the Channel to the Shetlands. Outside Britain the Coelopidae are flies of temperate and sub-arctic shores, of both the Northern and Southern Hemispheres. The known distribution of *C. frigida* is shown in Fig. 2, and extends from the Bay of Biscay well into the Arctic Circle, and in comparable latitudes in the western Atlantic and in the Pacific.

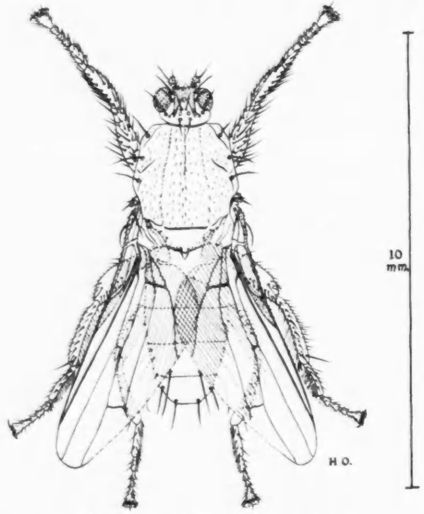

FIG. 1. The Seaweed Fly, *Coelopa frigida*.

It is easy to find *Coelopa* on the beach. If you stir any neglected heap of rotting weed, at any time of year, you will disturb a number of rather grotesque, bristly flies, which walk over the weed and take flight for short distances. This fact is well known to holiday-makers who take their chairs on the beach, but provided the weed is not disturbed it is only rarely that the flies become really troublesome. Besides *C. frigida*, the seaweed generally harbours at least one other species of the family Coelopidae, together with other flies that specialise in this particular habitat, notably Muscid flies of the genus *Fucellia*, which look much like houseflies; a tiny black fly, which is the Borborid *Thoracochaeta zosterae*; and the Dryomyzid *Helcomyza ustulata*, which will be referred to later.

The general appearance of *Coelopa frigida* is shown in Fig. 1. It is a dull black or black-brown fly, dorso-ventrally flattened, i.e. it has a permanently squashed appearance. The brownish legs and head are excessively bristly, but the thorax has long bristles only at the sides; on its upper surface (the mesonotum) it is covered with very short, spiky, backwardly projecting bristles, some of which are arranged in three distinct rows, while the rest are distributed at random. The wings, which are clear, with only a faint brownish tinge, have no very striking features, though there are detailed points of detail in the venation that help in identifying the family.

In size *C. frigida* is exceptionally variable, and may be as small as 3 mm. or as large as 11 mm. It is sometimes difficult to believe that two extreme specimens can belong to the same species, and a number of different names have been created in the past. Work by Mayhew (shortly to be published) establishes that only one species is involved, and that its bristliness varies with its size.

There are four other Coelopidae in Britain, all common, and often abundant locally. *C. pilipes* resembles *C. frigida*, but with the bristles of head, legs and tip of the abdomen replaced by a furry pile of long, fine hairs; *Orygma luctuosa* and *Oedoparea buccata* are very much less bristly, especially about the head, and the latter species is mainly orange in colour; *Malacomyia sciomyzina* is consistently smaller in size than the average *C. frigida* (which is 4 mm. long), has a yellow head and legs, and is not outstandingly bristly.

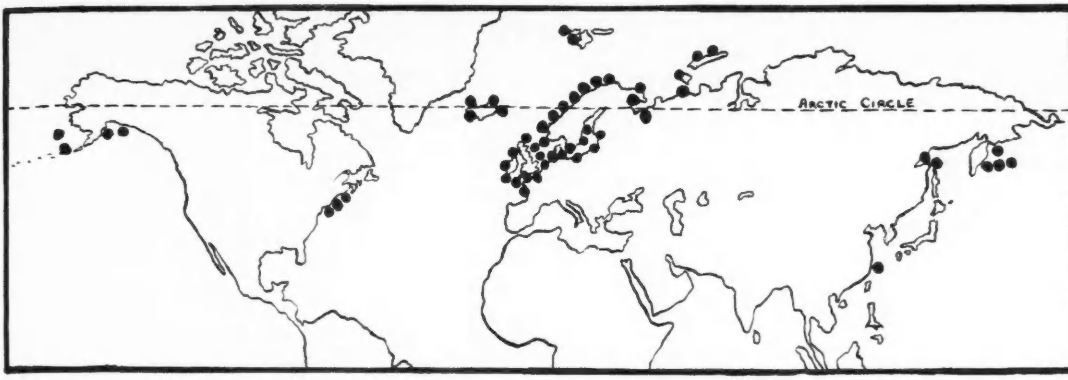

FIG. 2. The distribution of *Coelopa frigida*, as given by Hennig (1937).

Although these Coelopids are distinctive when seen in their natural surroundings, there are inland flies—notably of the families Lauxaniidae (Sapromyzidae) and Dryomyzidae—that are difficult to distinguish from them without a specialist's eye. There is one Dryomyzid (*Helcomyza ustulata*), that occurs on the beaches, and looks like a bigger and more bulky *Coelopa*, covered with silvery dust. Hence it is necessary when *Coelopa* is reported away from the beach, to check the identification very carefully.

EARLY STAGES

There are the usual stages of egg, three larval instars, and a pupa. The larvae are maggot-like, differing from the great range of similar maggots only by the pattern of the unusually protruding hind spiracles, which can also be seen on the pupa (Fig. 3). The larvae and pupae are to be found among the rotting weed, either in the heaps, or among the shingle immediately below.

An obvious question to ask is the length of the various stages of development, but to give a reliable estimate of this under natural conditions is difficult. Laboratory figures vary among different authors. Elwes (1915) found that the eggs took sixty hours to hatch, the larval instars about a month, and the pupal period about a fortnight, making some six weeks in all. Hennig (1937) says he has not observed a pupal period of longer than six days. Unpublished information given to me by Mr. Mayhew indicates that a shorter total period, in the region of twenty-one days, is possible, and this is close to the general average for higher Diptera in summer temperatures.

Like other flies, *C. frigida* must have a minimum period in which its pre-adult stages can be completed, even under the most favourable conditions. Its actual period under any given circumstances must depend upon what adverse factors come into play, of which the most usual are unsuitable temperature, wrong humidity, and lack of food. By selecting a compost-like medium for breeding, *C. frigida* has largely insured itself against the first two, and consequently the last factor—shortage of food—is probably the most important one in affecting the rate of reproduction, and regulating the total population of the fly.

THE LARVA'S FOOD

The exact food of the larva is not known, but it appears that it feeds upon the slimy products of decomposition of the seaweed, and does not eat holes in it like a caterpillar on a leaf. Backlund (1945, p. 123) says that the larvae cannot live on sterile seaweed, and "always died if not so mature that they could pupate within some days". Eggs placed on sterile seaweed hatched, but the larvae did not survive. The implication of this should be noted: the amount of food available in a given place is not necessarily governed by the total amount of stranded weed, but by its state of decay.

The position so far, then, is that this endemic fly breeds in the specialised medium of rotting seaweed, and its numbers are governed less by the direct effect of fluctuations of air temperature and humidity—against which it is largely protected—than by their indirect effect in promoting the decomposition of what seaweed there may be washed up on the beach.

ACTIVITIES OF THE ADULT FLY

The nuisance value of this fly attaches entirely to the activities of the adult. The mere number of adults is not important, so long as they stay quietly in the weed-heaps and among the shingle. In practice large populations of flies are often present in such places, but are overlooked until they are stirred into activity. One way in which this may occur naturally is by the rising tide flooding up through shingle, or floating the weed-heaps on a shelving beach. The adult flies are well adapted to this, and not only float easily to the surface of the water unwetted, but are able to take off from it without being trapped by surface tension.

If there is room, the flies may merely settle again higher up the beach, but at times they are well known to assemble in swarms and to fly along in a sort of column, a foot or two above the beach. They may continue for

some time in a steady direction. Some observers think that the general trend is from west to east, but I think that the resultant movement is a combination of a more or less purposive flight parallel to the beach, and an involuntary drift downwind.

The flights generally keep fairly close to the beach, but sometimes lose contact with the foreshore and travel inland for one or two miles. Miall (1903, p. 373) says: "They occasionally fly a few miles inland and visit flowers", and this has been noted occasionally since that date.

The activity, and hence the nuisance value, of the adult flies is very closely related to air temperature, or to brightness; they are active on warm, sunny days, and on dull, cold days they retreat into the shelter of the weed, or among the shingle. Backlund considers that brightness is more significant than air temperature, pointing out that the temperature at night in summer may be higher than the day temperature in winter, when the flies are still active. Two of his assumptions seem to be doubtful. The flies can, and do, breed through the winter, but their aerial activity is confined to warm spells, even momentary ones. On the other hand he assumes that activity at night is negligible: "At 10 p.m. . . . the flies were very languid; even when I touched them they would not fly away, but only tried to hide further down in the wrack". This is contradicted by the fact that in late October, 1953, I identified specimens from a big swarm round the lantern of a lighthouse in Co. Donegal, at night.

It seems probable, therefore, that air temperature is the more important factor, and that, like many other Diptera, they may be more active on warm nights than is generally realised.

ATTRACTION TO CHEMICAL ODOURS

Among its other idiosyncrasies, *Coelopa frigida* has one which is not shared by all members of its family, though *Malacomyia sciomyzina* has it too. Trichloroethylene, chloroform and carbon tetrachloride are

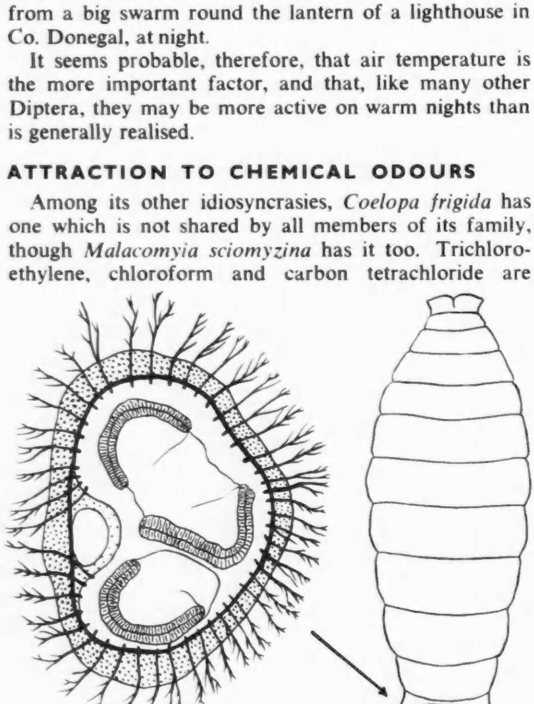

FIG. 3. Pupa of *C. frigida* (right): on the left is an enlarged view of one of the two hind spiracles.

irresistibly attractive to the flies. Why this should be so is not clear. Certainly seaweed contains halides, and the attractants are heavily chlorinated, but there the resemblance seems to end.*

Since these solvents are widely used in dry-cleaning, as de-greasing agents in engineering works, as solvents in plastics manufacture, and in adhesives used in many light industries *Coelopa frigida* can be a great nuisance if it congregates in rooms where they are used, or masses round vent pipes through which extractor fans discharge. Certain paints and a few detergents may attract them, as well as the characteristic mixed odours of pharmacists' shops.

Reports of outbreaks of *Coelopa frigida* are not new. Every year a few complaints are received from seaside towns that a swarm is infesting a chemist's shop, or a dry-cleaners, or a small works. Always one can point to the odour as the attractant, and the beach as the source of the flies. The outbreaks are most usual in late summer or autumn, after the seasonal gales have brought in weed which is heaped on the beach and quickly rots. These local outbreaks are temporary, and come to an end when the weed is removed, either by carting it away, or by the next spring tide which washes it into the next bay.

THE AUTUMN OF 1953

In 1953 complaints of abnormal numbers of the flies along the south coast began in September, and continued until early December. The appearance of so large a population of flies was spectacular, and it is not surprising that it was first reported as an invasion from abroad. Looking at it correctly as an unprecedented build-up of an existing population, we have to look for a corresponding increase in the amount of larval food available, since we have already agreed that this is probably the important factor governing reproduction of the fly. We have evidence for that: the great quantity of wrack on the south coast has become a matter of concern in recent years, and in 1953 we had an unprecedentedly long and mild autumn to maintain the rate of decay of the weed.

It is possible that the outbreak was not entirely the work of one season, but that populations of the fly have been running higher than average for several years, as a result of the increasing amount of stranded weed. The particularly favourable conditions last autumn brought about the final rapid multiplication.

OCCURRENCE IN THE LONDON AREA

A fortnight or so after the flies on the south coast became news, *C. frigida* appeared in the London area. Sanitary inspectors between Wimbledon and Wembley reported outbreaks of a new fly, strictly confined to premises using one of the organic solvents mentioned

* Decomposition products containing chlorine or iodine might arise through fermentation of seaweed, a matter which has received little attention. (One of the very few communications on the decomposition of seaweeds and seaweed products was Prof. C. G. C. Chesters's lecture to the Linnean Society of Jan. 21, 1954.)

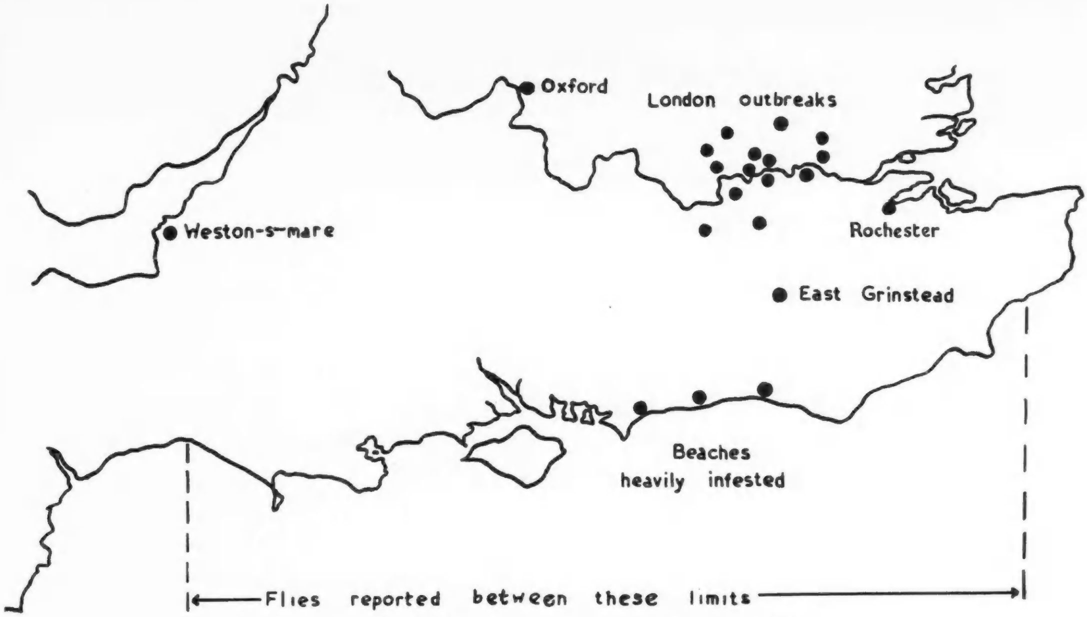

FIG. 4. Outbreaks of the Seaweed Fly in the autumn of 1953.

earlier. The fly was *Coelopa frigida*, and its habits were perfectly in character, and exactly predictable, except that they were taking place this time forty miles inland.

As 'coelopiasis' is not a notifiable infestation, there is no complete list of records of the occurrences inland, but Fig. 4 gives a fair picture of the probable distribution. Note that the reports from west London came a little before those from the east and north-east, and that the northern limits known to me are Mill Hill and Oxford (where enough were collected to start breeding experiments on seaweed).

The London flies seem to have been derived from the south coast, and not from the Thames Estuary. The nearest point in the Estuary at which normal, littoral breeding occurs is Canvey Island, and there numbers were not phenomenally large, though the adult flies were a nuisance at times in the warm autumn weather. The outbreak at Rochester should, I think, be looked upon as linked with the London group: the record from East Grinstead, almost exactly half-way between London and the south coast, supports this view.

The flies persisted for four or five weeks, if not more, in the London area. A few have been taken in March, 1954, but the big swarms of the autumn have not reappeared at the time of writing. It seems likely that the few specimens seen are stragglers from the autumn, which have overwintered in a sheltered place, as do the Cluster Fly and several other species that hibernate as adults.

How did the flies reach London? The simplest answer is that they probably flew there, or drifted with the wind. The mild weather of the autumn was associated with persistently southerly or south-westerly winds. Objections have been raised that the distance is too great; that there is a big gap in the records between the coast and the inland group; and that it has never happened before. To the first we may reply that insect movements are known over much greater distances; to the second that the presence of the flies is only detected when they congregate where some odour attracts them, and that great numbers could be present in open country without being noticed; to the third that the presence of such large numbers on the south coast, coupled with southerly winds, is a rare occurrence, and it probably last occurred when these chemicals were not in general use, and when flies were more tolerated generally than they are now.

DO THE FLIES BREED INLAND?

No one can categorically deny that *C. frigida* might be capable of breeding in compost or vegetable refuse, but we are bound to point out that even if it were doing so the problem of how it got to London to do so would still be unsolved. It would merely be antedated. Now that the flies are here (or have been recently), they might conceivably breed locally, but it seems unlikely that they would do so for the following reasons:

1. Because it would reverse their evolutionary trend. The Coelopidae are closely related to other flies that do breed on rotting vegetable matter inland, but by specialisation they have become adapted to the requirements of the wrack as a breeding medium. All previous work on the group shows them as intensely attached to their special niche, and it is difficult to imagine why they should suddenly choose to leave it; and why, if they did so, they should leap all the way to London, instead of colonising the hinterland gradually.

2. This is not likely to be the first time they have spread temporarily inland. Although uncommon, the

combination of circumstances that existed on the south coast last season is not unique, and must have occurred in the past, though perhaps not recently. If we look at Constable's paintings of Brighton Beach about 1824 we cannot imagine that a few flies would cause a great furore, whereas today, with much bigger coastal resorts, and a higher standard of hygiene, we are rightly more fly-conscious. And if such outbreaks occurred in the past it is likely that the flies also spread inland, but in the absence of odours to attract them the flies would not be detected. The widespread use of these organic solvents is of comparatively recent origin.

Mention has been made in the Press of experiments in which *C. frigida* was reared on brussels sprouts and other vegetables. These must be given due weight. If gravid females were induced to lay on vegetables; if the eggs hatched, the larvae thrived and pupated, and the adults emerged successfully then such breeding is physiologically possible. It still remains true that the fly does not normally make use of such media, though they abound near the coast, and it is hardly likely to do so just because the idea has now been put into its head; in the free state it must be inhibited by some factor of behaviour, such as the absence of an attractive odour.

On the other hand, if partly fed larvae were taken from seaweed, where they were flourishing, and placed upon vegetables, and if they remained small and eventually pupated to give undersized adults, then nothing is proved. They might well have already stored the minimum of food to enable them to complete development, and would have done as well without any vegetables at all. Backlund's experiments with sterile seaweed are relevant to this: the larvae "always died if [they were] not so matured that they could pupate within some days".

THE PROSPECT FOR 1954

Three factors are involved: how many flies survive at the end of the winter; how much weed lies on the beach, and for how long; and how hot the weather is to hasten decomposition, and to activate the adults, thus increasing the nuisance. There seem to be three possibilities:

1. *No weed*, or none left long enough to rot—No Flies.

2. *Weed, but no flies*, due to spraying. Again no flies, but spraying will have to be continued at intervals sufficiently frequent to stop recolonisation from the next bit of coast. The flies can never be exterminated from the whole coastline of the British Isles, of which there are 2751 miles in England and Wales alone; after that there is still the Continent to draw upon.

3. *Weed + flies*. The outcome depends upon that important factor of food for the larvae, which means total quantity of rotted weed, and which again means a combination of quantity of stranded weed, length of time it lies there, and weather conditions to promote decay. This is the real key to the problem.

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THE MIGRATION OF MAMMALS

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When I was asked to write of the migration of mammals my first thought was, "hardly any of them do"—and compared with birds, the proportion of the eight thousand different sorts of mammals that have regular migrations is certainly very small. In fact the characteristic thing about the majority of mammals is not that they migrate but how near home they stay. Many mammals have a home range—a *territory*—in which they spend practically the whole of their lives, and from which they seldom or never wander. This applies particularly to those small mammals that live in burrows, or nests, which form the centre of their territories. The normal range of the common Long-tailed field-mouse, for example, covers only a trifling area, and it is unusual for an individual to travel more than a hundred yards from the centre of its territory. Rabbits usually live their whole lives in the warren in which they are born, and do not go more than two or three hundred yards away for their daily grazing. This attachment to territory also applies during the breeding season to the more nomadic kinds as well, for many animals that may be considerable wanderers for part of the year have to become static when their young are born, and have to make a home in which they can be reared.

Carnivorous mammals usually have a hunting territory centred upon a home, a den of some sort. They work this territory but do not need to go beyond its bounds. Their food is concentrated high-grade protein, and they may need to make a kill only at intervals of several days. Unlike the herbivorous mammals they are not compelled to be always feeding.

The larger herbivorous mammals—the grazers and the browsers—must feed on and off all day, because the green herbage they eat has a comparatively low food value. So the larger sorts must have a wide grazing range, and in consequence their territory is often not well marked. In Africa, for instance, many of the grazing mammals follow the rains and the new grass

FIGS. 1 and 2. Photographs of Lemmings taken by Frances Pitt in Norway. The animal on left is an adult; that on right is somewhat more than half-grown.

that springs up afterwards; they thus undertake an irregular sort of migration through an extensive but ill-defined territory.

There are, however, mammals that make regular migrations similar to those of birds. In these there is a seasonal movement of the whole population, with a return at a later date: the movements are either to reach good feeding grounds, a more congenial climate, or a suitable place for breeding. But unlike the free-flying birds, land mammals have to make extensive and possibly difficult journeys on foot—rivers, mountains and arid regions are insuperable barriers to travel, so it is not surprising to find that comparatively few land mammals migrate. They are mostly the large and long-legged sorts that can travel fast and so can protect themselves from predators and other hazards of migration. It is especially the mammals that live in a uniform medium that are able to migrate on a scale comparable with that of birds. They are the mammals that live in the sea and can swim, or live in the air and can fly: the whales and seals on the one hand and the bats on the other.

Let us consider first the land mammals. The mammals that migrate on foot must obviously be those that live on the large continental land masses, if their travels are to extend to any considerable distance. Land migration, too, must obviously be over ground that is reasonably good for travelling; apart from topographical barriers such as mountains or deserts, tropical forests are almost impenetrable for anything but local movements.

It is in N. America particularly that we find several species of land mammals that migrate; by contrast, in Asia, Africa and Australia there are few. There is good reason for this. It is probably correlated with the topography and climate of the continents. In N. America there are great differences of climate in different latitudes, and in addition the main mountain masses run north to south; in Asia the hotter south is divided from the cooler north by mountain ranges running east and west: in Africa the climate varies from sub-tropical to tropical but there are no arctic regions from which a winter migration might be necessary. In Australia the largest mammal is no bigger than the kangaroo, and the enormous arid area of the central desert debars it and every other terrestrial mammal from migration.

In N. America the larger migratory mammals traverse lands that are open steppe or savannah, or are covered only with comparatively open forests. The American mammal whose migrations have attracted most attention is probably the caribou, a species of deer like a large reindeer. But the movements of the herds are by no means constant and it is therefore very difficult to form a clear idea of its migration routes. In some years the herds mass together in great numbers so that the migration is an impressive sight; in others the herds are broken up and the deer pass by in small bands that give the impression of a scarcity. And the herds of different regions take different routes, so that they do not appear to obey any uniform rule. All that one can say is that in general they seem to follow a circular counter-clockwise course during the winter, and then to bear away north-west to the barren lands in spring. In the Mount

McKinley area of the Alaska range, however, the caribou that spend the summer on the southern slopes actually move over in the winter to the northern side where the snowfall is lighter. The migrations of the caribou are connected partly with the food that is available, but they are connected to an even larger extent with the appearance of the clouds of mosquitoes that make life a misery for man and beast. Shortly after the deer move north the mosquitoes emerge in almost incredible hordes, but as soon as the mosquito season is over the caribou return to their winter quarters and thus they miss the worst of the mosquito plague farther north.

The other large N. American migratory mammal was the bison. It was long doubtful whether the bison was a truly migratory mammal, but the analysis of a great mass of old records by the American naturalist E. T. Seton has plainly shown that it was. But here again the migration routes were not simply to and fro from north to south, but were more or less in circular clockwise paths, some of the herds joining one circuit, others another circuit. And the winter quarters of at least one circuit were in the northern part of the range, although other herds moved southwards from two hundred to four hundred miles at the approach of winter.

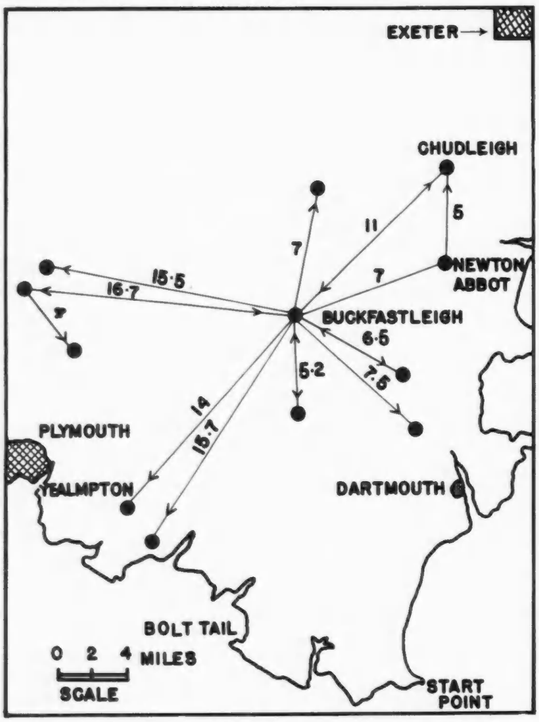

FIG. 3. Sketch map illustrating typical movements of Greater Horseshoe Bats in S. Devon. Figures include mileages; arrows indicate directions of flights (after J. H. D. Hooper; based on observations made by Mr. Hooper and members of the Devon Spelaeological Society).

Many other land mammals have similar seasonal migrations, though on a much smaller scale. Our own red deer move down from the higher hills during the winter to the less severe conditions of the valleys, but the distances covered in such movements are trifling compared with the journeys performed by birds, some bats, and the aquatic mammals. At the other end of the scale a migration to be measured in yards rather than miles occurs every year when in the autumn our population of feral House-mice moves in from the fields to the corn stacks. Such local movements of limited extent are commonly found in the smaller mammals.

THE LEMMING

A kind of population movement that should not be confused with true migration, which is essentially an outward followed by a return journey, is the periodical emigration that is found in some species. In this there is an outward journey, but no return; the animals that quit the land of their birth perish and leave no offspring to come back. The most familiar example of an animal that emigrates is the lemming of Scandinavia. Lemmings are small mouse-like rodents that normally live high up on the Norwegian mountains close to the timber line. Their numbers, like those of many small rodents, are subject to periodical cycles of increase and decrease, which may reach an astonishing size; as their numbers increase the population is crowded out of its normal range and overflows down the hillsides. Finally, when it reaches a peak, there is one of the famous 'lemming years', when the animals swarm all over the countryside, moving of necessity in a westerly direction. Thousands are drowned in the rivers and fjords; and then the population crash comes and they die out, leaving comparatively few survivors on the hills to start building up towards the next peak. Similar cycles, though on a smaller scale, are known in other rodents, for example our own Short-tailed Vole and the American Grey Squirrel. The journeys of vast hordes of springbok that used to occur in the appropriately named *Trekkbok* years in S. Africa were also emigrations, and not true two-way migrations.

But none of these terrestrial mammals can undertake migrations similar to those that are so well known in birds, where a whole population transfers itself in a few days or weeks over a great distance, often hundreds of miles, to a seasonal territory, and where the dates of arrival and departure vary only within narrow limits. It is only the mammals whose movements are unrestricted, because they fly in the air or swim in the sea, that can make migrations in any way comparable with those of birds.

A few species of small bat make regular migrations from summer quarters in the north to winter ones in the south, although most bats seem to get over the difficulty of having no winter supply of insects to feed upon by giving up the struggle and hibernating. Some, however, particularly in America, do not hibernate, but migrate far to the south to warmer regions where food is abundant. Two species in particular are known to

migrate, the Red Bat and the Hoary Bat. They spend the summer in the northern United States and migrate down the Atlantic seaboard of America to the south-eastern States in the winter. There is no doubt about the southern migration, for the bats have been both seen and captured on their passage, not only on land near the coast but far out at sea. But hardly any have ever been seen on their return journey, and beyond the fact that they are present in the north again during the summer, there is little direct evidence to demonstrate their northern journey. Some of the European bats, too, are said to migrate but the known facts prove only that a local movement takes place, and no long-distance travels have been shown to occur. None of our British bats migrate to other countries for the winter; they all hibernate. But the hibernation of some of them is not so complete a winter sleep as has been sometimes thought. Members of the Devon cave club have recently marked a very large number of Horseshoe Bats with aluminium rings so that they can follow up their movements. The result of this work shows that although the bats hibernate, they keep on waking up at intervals during the winter, and sometimes travel distances of many miles from one cave to another during these wakeful periods. Horseshoe Bats live in caves during the winter, but they migrate to other quarters in the summer; no one knows quite where, but it is certain that many of them take up residence in such places as the roof-spaces above the attics of old houses, and the roofs of churches.

In the tropics there is a well marked migration in some species of large fruit-eating bats, or flying foxes as they are called. In the Grey-headed Bat of Queensland there are regular mass movements of large parts of the population. In Australia, the forest areas where they hang up to sleep are known as 'camps', and flights of many thousands of bats pass from one camp to another on their journey to the extreme south-eastern part of Australia where they spend the summer.

But the extent of these aerial migrations is surpassed by those of the mammals that live in the sea, the seals and the whales. The most spectacular migration among the seals is that of the Fur Seal that breeds on the Pribilof islands. The islands lie two hundred miles off the coast of Alaska north of the Aleutian islands, and on them the Fur seals haul out in almost incredible numbers every breeding season. The old bulls arrive first and take up their territories; then the cows come and give birth to their pups a few days or even a few hours after their arrival. Each bull collects a harem of females over which he keeps watch, driving away any rivals that may try to poach on his territory. While the cows are nursing they go to sea to fish, and return every day or so to feed their pups, but the bulls remain at their posts for about three months without feeding. At the end of the season the old bulls move off to their winter quarters south of the Aleutians and in the Gulf of Alaska, but the cows, the pups and the young bulls go much farther, and winter as far south as the latitude of southern California, successfully making a journey of

FIG. 4. A Long-eared Bat marked with a numbered aluminium ring. Devon 'cavemen' have ringed over 1800 bats belonging to seven species.
(Photo by J. H. D. Hooper)

three thousand miles across the open ocean and not by following the coastline. Many other kinds of seal, though not all, have similar migrations perhaps on a rather smaller scale, though as yet little is definitely known of them.

Many kinds of whale make regular seasonal migrations over great distances. In the southern oceans the gigantic Blue Whale, the Fin Whale, the Humpback and others perform regular journeys during the antarctic summer, to the far south, where they feed upon the rich plankton that swarms in those cold seas at that time of year. And then they depart to the north, and spend the winter in temperate and sub-tropical seas, where they feed very little or not at all while their young are born and nursed through the early weeks of life. In these migratory journeys whales cover many thousands of miles far away from any land so that there is no possibility of obtaining any guidance by following the lines of a coast.

The migrations of the sea mammals thus differ from those of terrestrial ones, which are not only limited by topographical features of the land but might also be guided by the recognition of landmarks. The marine mammals can have no such influences to guide them on their journeys.

How then do they do it? Frankly, we just do not know; none of the many theories that have been put forward to explain such migrations seems to me to be adequate. People were once content to say 'instinct' and leave it at that, but the expression was no more than a

confession of ignorance. The invocation of the Coriolis force has been shown to be untenable as an explanation of the orientation of birds during migration*; it would be even less applicable to the more slowly moving migrating mammals.

Much thought has been given to the possibility that migrating birds navigate by observing the position of the sun or other heavenly bodies; if birds *can* navigate by that means, why not mammals? It seems to me that there has been some confusion of thought here. If an animal is to navigate successfully it must have a knowledge of where it is, and of where it is going—that is to say it must have some kind of geographical knowledge and some kind of mental image that corresponds to a map. If it *had* this knowledge, it *is* conceivable that the altitude of the sun might give it some rough idea of its latitude on its mental map. But it seems to me quite impossible that it would in any way be able to determine its longitude, however roughly. I do not suggest, of course, that an animal would have any conscious conception of these co-ordinates, but fixing a position on a map of any sort implies the use of them, even if it is unconscious. Furthermore, any suggestion of navigation implies the knowledge of a destination and of its approximate position; it seems to me very improbable that any animal can have that knowledge. And some animals that migrate singly and alone certainly *cannot* have it, for instance the young of some birds that migrate over routes they have never travelled, to places they have never visited, long after their parents have deserted them.

We know that some insects orientate themselves by the position of the sun, and that they can do so even when the sun is obscured by cloud because they are sensitive to the polarised light impinging on them. But this orientation serves only to take them to and fro between home and foraging grounds that they have discovered by random search; an experience, if not a knowledge, of both ends of the journey is implied, and the distances covered are furlongs at most, not thousands of miles. It seems to me improbable that migrating mammals can be guided by such means.

It is of course possible that migratory animals have some sense of direction that we have not. The way in which cats and dogs, and some kinds of birds, sometimes return to their homes over great distances after they have been removed in closed containers, so that they can have no possible guidance from a memory of the route travelled, lends some support to this suggestion. If animals do have a perception that is lacking in ourselves, we can no more hope to understand it than a man blind from birth can understand what is meant by 'colour'. But a sense of direction would presumably need some sense organ for the reception of stimuli of some sort—no animal can be aware of its environment, or even of itself, without the appropriate receptor organs. No such receptors are known to us. It is possible, but not probable, that animals do have receptors of this nature and that we do not recognise them—lacking that sense we overlook them.

Have we any remains of a sense of direction that might have been more highly developed in our remote ancestors? It seems improbable that we have any idea of direction if we are cut off from all visual or other perception of the route we have travelled. Of course, if you were carried blindfold to the middle of England and told to make your way across country to London you might succeed in hitting it off roughly by noting the position of the sun, even if there were no signposts and no one to tell the way. But that would be because you carry a memory of the maps you have seen, and know that you are in England: if you were similarly placed in France, but thought you were in England, you would have considerable difficulty in finding your way until your knowledge of geography and topography showed you that you could not be in the country you thought. There seems to be no evidence at all that we have any inherent sense of direction apart from immediate experience of our surroundings. If animals have any such sense we do not share it.

There has been some discussion about the possibility that birds may be able to orientate themselves on migration in relation to the earth's magnetic field, that they have some sense organ that is effectively a compass. Some experiments were carried out with homing pigeons; small magnets were fixed to them to find out whether any effect could be produced thereby upon their homing abilities. The results were entirely negative, and moreover other experiments have shown that birds appear to orientate themselves according to the true points of the compass rather than the magnetic ones. It is improbable that mammals differ in this point.

We know, therefore, something of the facts about the migrations of some mammals, but the means whereby migration is carried out still remain completely unknown; many theories have been tried but none of them has been capable of experimental proof. It is all very puzzling; as far as we know the bodies of the other mammals are essentially similar to our own, and we flatter ourselves that our brains are more highly developed. And yet these animals that we classify as lower than ourselves can do something, and presumably with their brains too, that we cannot; something so far outside our own experience and abilities that we cannot even conceive how they do it. Natural selection has no doubt fixed the tendency to migrate in those species where it is found, but that does not explain how it is accomplished. There is obviously much more to be found out about the migration of animals than we have yet discovered.

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ARE SEA-SERPENTS GIANT EELS?

MAURICE BURTON, D.Sc.

It is thirty years now since I first became interested in stories of the sea-serpent, and during that time I have neglected no opportunity of discussing the subject, either with believers or disbelievers. The former are more numerous than is commonly supposed, and can be divided into two categories: those who, on an ocean voyage, have seen something which they can only ascribe to some unknown animal of giant size; and those who, having examined the evidence, find it credible, but for fear of ridicule prefer to maintain a discreet silence. The evidence includes a welter of optical illusions, practical jokes, hoaxes and imperfect observations, yet, when all these are dismissed, there remains a hard core of detailed descriptions by competent observers which cannot be lightly put aside. There is another striking thing: that the evidence for both the sea-serpent and the Loch Ness Monster is remarkably similar in all particulars. Both refer to a moving object—a living beast presumably—of considerable length, moving at speed, and remaining at the surface for a short time only, during which the most distinctive feature is a series of humps showing above the water-line.

There is nothing in the more reliable stories that is beyond belief except those humps. They form the big obstacle for the zoologist, who rightly points out that it is highly unlikely that a beast of such dimensions could produce the vertical undulations in its spine necessary to give this effect.

Some years ago, while pondering this problem more intently than usual, I came to the conclusion that giant eels were probably responsible for all the stories about sea-serpents and the Loch Ness Monster. They are the only known animals equally at home in salt or brackish water—or even fresh water in some cases—that are sufficiently amphibious to be able to keep the head out of water for the length of time required by the various reports, and which habitually lurk at the bottom, making only infrequent and sporadic appearances at the surface. Within recent years, eel larvae 3 ft. or more in length have been discovered in the sea. The larva of our common freshwater eel is 3 in. long, and grows into an adult 3 ft. or more in length. It is a matter of simple arithmetic that, if the proportions are preserved, a 3 ft. larva could grow into an adult 36 ft. or more long. Size, then, is no obstacle to the acceptance of these persistent stories; nor speed, as anyone will know who has watched a conger swim. Only the humps remain, the sole obstacle to acceptance.

It was when reviewing these things, then, that it appeared worth my while to assume that the stories of the sea-serpent and the monster might be true; and, starting, from this premise, to see if the problem of the humps could be solved. If, for example, eels ever swim at the surface and on their sides, the appearance of a series of humps could be expected. Accordingly, I got into touch with as many angler friends as possible, to see if any one of them had seen an eel swimming in this way. None could recall seeing an eel at the surface.

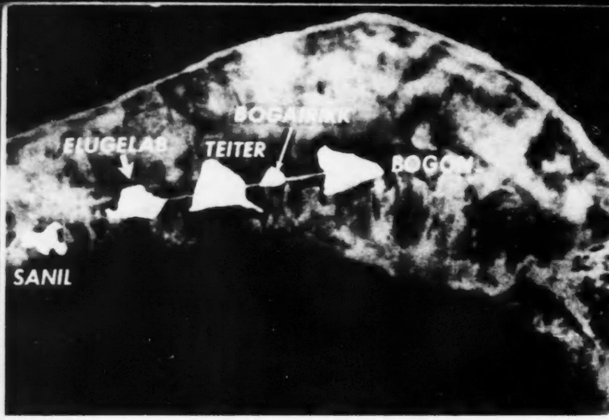
It happened that a little later I was making a commentary for a film of life under the sea. It was on a Saturday afternoon towards the end of this task, while watching a piece of the film that I had seen again and again, a scene of a conger swimming over the bottom of the sea. Then something suddenly struck me, and I asked for this portion to be run through again. The conger was swimming at speed, on its side, the body undulating as it slid over the rocks, an inch or two above them.

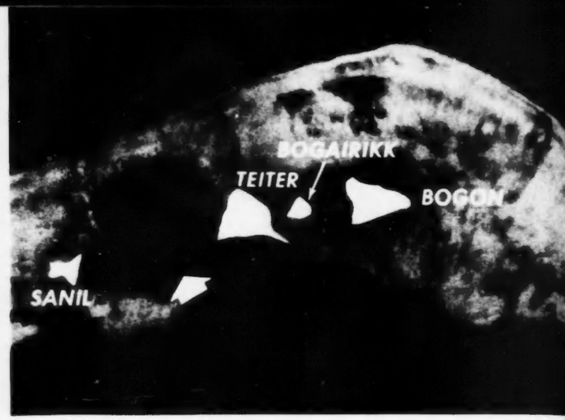
As soon as possible I went to the Aquarium at the London Zoo—choosing the Monday, when there would be few visitors—and stationed myself before the large tank containing the conger eels. In the tank were half a dozen eels, the longest some 5 ft. in length. For half an hour nothing happened, except that one smallish conger, with its head thrust in a crevice in the rock, leisurely twisted the hinder half of its body into the horizontal position and slowly undulated just that part of it. A little later, a larger eel that had, up till then, been lying on its back, periodically yawning, rose bodily in the water, until a foot or so off the bottom, turned on its side and vigorously undulated its body, the waves passing along the body producing a series of humps from head to tail. It was all over in seconds and the eel sank languidly to the bottom, turned on its back and resumed its yawning.

During the next half-hour, several queer things happened. One of the smaller eels, $2\frac{1}{2}$ ft. long, rose from the bottom of the tank, gently tilted its body until it was suspended in mid-water head down. Then it glided to the surface until 9 in. of its tail protruded vertically above the water, in which position it swam gently along. A larger eel doing this, with 6 ft. of its tail erect above the surface of the sea, would produce an appearance difficult to interpret, or to have believed.

Several such things occurred, but the most important thing was still to come. As I was about to turn away, a 5 ft. conger, hitherto quiescent in a drain-pipe lying on the bottom of the tank, emerged and swam slowly and effortlessly around at about mid-water for about ten minutes. Then it suddenly rose to the surface, turned on its side, undulated its body violently, causing a flurry of water and a series of humps above the water-line. Then it slowly sank to the bottom into the drain-pipe and settled down once more to rest. Meanwhile, the surface of the water, left in violent agitation, slowly subsided. A really large eel carrying out such a manœuvre would give a picture of the sea-serpent.

(*This is an excerpt from Dr. Burton's latest book, "Living Fossils", published by Thames & Hudson, price one guinea. Dr. Burton's idea about sea-serpents coincides with that of Anton Bruun of the recent Danish ("Galathea") deep-sea expedition, which dredged up a 6-ft. long eel larva with 450 vertebrae, three times as many as the figure for the largest known eel.*)

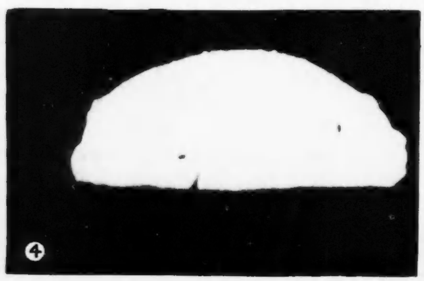


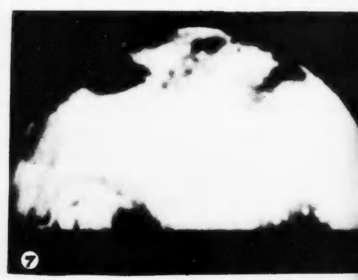


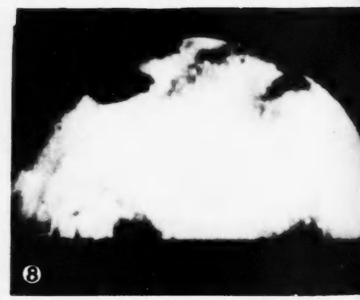
THE EXPLOSION THAT WIPED OUT AN ISLAND

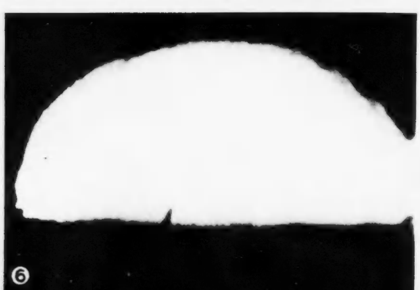
The U.S.A. exploded its first hydrogen bomb code-named 'Mike', in November 1952. In this test explosion the island of Elugelab completely disappeared leaving a sea-filled crater one mile wide and 175 feet deep at the centre.

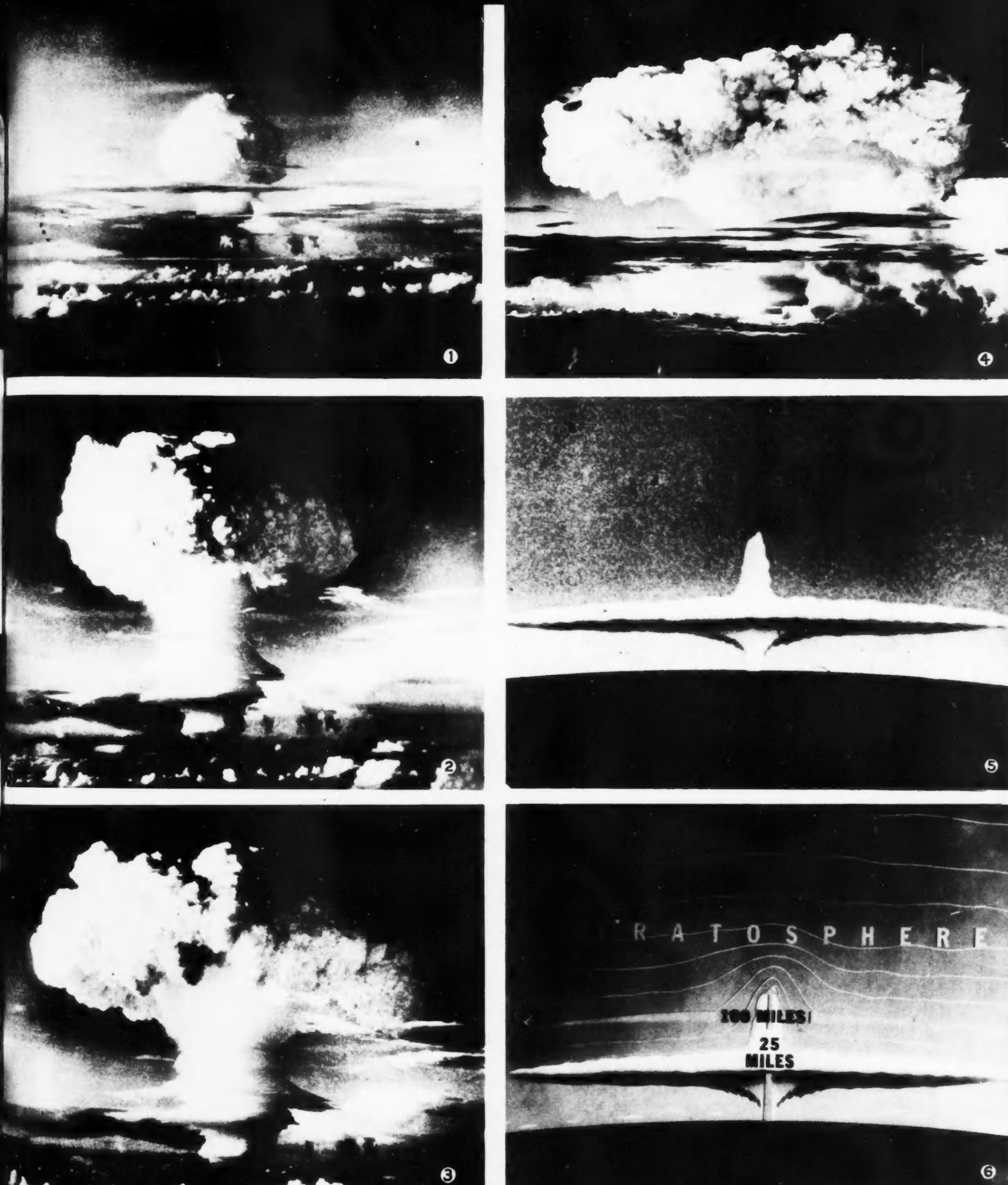
(*Below*). These nine frames from a film record of the H-bomb explosion show stages in the development of the fireball until it reached a size of 3½ miles in diameter.











The intensely radioactive cloud from the Elugelab H-bomb explosion. Two minutes after the detonation the cloud had reached a height of 40,000 feet; ten minutes later the stem of the cloud had pushed its way 25 miles into the stratosphere. The radioactive mushroom went up to 10 miles and then spread out over 100 miles; this is seen in the penultimate picture in this series (which is a frame from the film record of the explosion) and the dimensions of the cloud are given in the final picture.

FAR AND NEAR

Night Sky in May

The Moon.—New moon occurs on May 2d 20h 22m, U.T., and full moon on May 17d 21h 47m. The following conjunctions with the moon take place:

4d 13h	Venus in conjunction with the moon	Venus	3° S.
5d 20h	Jupiter ..	Jupiter	2° S.
16d 07h	Saturn ..	Saturn	8° N.
21d 08h	Mars ..	Mars	1° S.

In addition to these conjunctions with the moon, Mercury is in conjunction with Aldebaran on May 19d 11h, Mercury being 7° 2′ N., Venus is in conjunction with Jupiter on May 23d 12h, Venus 1° 5′ N., and Mercury is in conjunction with Jupiter on May 31d 19h, Mercury 2° 2′ N.

The Planets.—Mercury is in superior conjunction on May 8, and is too close to the sun to be seen till later in the month; on May 15, it sets at 20h 25m, which is about 40 minutes after sunset and will not be easily seen, but at the end of the month it sets at 22h, or nearly 2 hours after sunset, when it may be seen in the western sky. Its near approach to Jupiter on May 31 has already been pointed out. Venus, an evening star, sets at 21h 25m, 22h 05m and 22h 30m on May 1, 15 and 31 respectively, stellar magnitude varying from $-3{\cdot}3$ to $-3{\cdot}4$ and the visible portion of the illuminated disk from 0·922 to 0·855. The increased brightness of the planet, in spite of the decrease in area of the illuminated disk, is due to the decrease in distance from the earth—from 143 to 129 millions of miles. Mars rises at 0h 10m, 23h 30m and 28h 35m at the beginning, middle and end of the month respectively. Its eastward motion in the constellation Sagittarius is easily seen, but on May 23 it is stationary, and after this has a westward motion which, however, is so small that it will be difficult to detect with the naked eye. Jupiter sets at 23h 15m, 22h 30m and 21h 45m on May 1, 15 and 31 respectively, and moves during the month from E. of β Tauri to a little W. of η Geminorum. The conjunction of Jupiter on May 5d 20h has already been referred to, and on this date the moon sets at 23h 25m, so the close approach of the two bodies will be easily seen. Saturn rises at 18h 35m, 17h 35m and 16h 30m at the beginning, middle and end of May respectively, setting in the early morning hours, and makes a very close approach to $\varkappa$ Virginis towards the end of the month.

While looking at Saturn, the bright star α Virginis, generally known as Spica, will be conspicuous. A first magnitude star of a bluish-white colour, its brightness is its most conspicuous feature to the naked eye, but there is something more interesting still, unseen even by the telescope, about this star. It is a spectroscopic binary, which means that it has a companion so close to it that its presence is known only by means of the spectroscope, which detects the revolution of both stars round their common centre of gravity. It has been found that the time of revolution of Spica and its companion is about four days. There are many spectroscopic binaries in the heavens, but most of them have longer periods than four days, though some have periods of only a few hours.

Molybdenum Increases Maize Yield

Molybdenum is a trace element which certain plants seem to require if they are to yield their maximum crop. Field trials made by Mr. F. A. York, district agronomist at Glen Innes, New South Wales, show that the application of small quantities of this element increases the yield from maize considerably. In one experiment he found that the yield with molybdenum was 53 bushels per acre, as against 38 bushels with ordinary superphosphate fertiliser.

New Wing to Harwell's Radiochemical Laboratory

A new wing to the Radiochemical Laboratory at the Atomic Energy Research Establishment, Harwell, has been opened. This extends the facilities for work on chemical and metallurgical problems involved in designing new types of reactors for power production. The new wing will enable research and development work to be pressed ahead more rapidly.

Research Cruises of "Discovery II"

The Royal Research Ship *Discovery II* (Lieut.-Commander H. O. L'Estrange), belonging to the National Oceanographic Council, has been recommissioned, after being laid up since October 1952, and will make a series of voyages of about three to four weeks' duration in the North Atlantic. On the first of these short voyages she sailed from Harwich on March 31.

The physical work to be undertaken includes an ambitious attempt to measure and study deep-water movements in relation to density distribution and other factors; studies of surface drift currents in relation to wind; and, in conjunction with the weather ship *Weather Explorer*, research on wave generation and decay. The biological work will be mainly concerned with the development of new methods of sampling and observing deep-sea organisms. Experimental work will also be undertaken using the carbon isotope method for studying the scale of photosynthetic activity performed by plant life at different depths.

Prizes for Hungary's Scientists

Scientists figure prominently among the top awards made in this year's distribution of Kossuth Prizes in Hungary.

The highest prize (£900) goes to Academician ALADÁR BUZÁGH, the colloid chemist; DR. ALFRÉD RÉNYI, mathematician, for his work in the calculation of probabilities; IMRE LIPPMAN, for his work in the field of heart surgery; and DR. LAJOS KREYBIG, for his book on agricultural technique.

Other awards go to BÉLA OBERRECHT, chemical engineer, for work in streptomycin production; ZOLTAN CSUKÁS, doctor of agricultural sciences, for his book, *Study of Fodder*; ERNÓ KEMENESSY, for agricultural reclamation of the marshy territories of West Balaton; PROF. EDE KUND, for work in farm mechanisation, including the construction of a machine for the cross-sowing of maize and an ergot-gathering machine; KÁLMÁN LISSÁK, for organising research into the connexion between the cortex and the deeper cerebral centres; REZSÖ MAUCHA, for developing new methods of taking samples of water and limnological examinations; REZSÖ SÓÓ, for his book, *Study of Plants in the History of Development* (1953); TIBOR DOMBAI, director of the Eötvös Lóránd Geophysical Institute, for work in seismic research and in the manufacture of geophysical instruments in Hungary; PROF. PÁL RUBÁNYI, for introducing surgical techniques; BÉLA MOLNÁR, of the Köbánya Drug Factory, for work on vitamin production.

A Radioactive Ore Detector

A portable radioactive ore detector (Type N 533) is being marketed by Ecko Electronics Ltd. of Southend. Incorporating a Geiger Muller tube, this new instrument has a miniature high-gain amplifier which, through headphones, gives a clear audible indication of the presence of radio-activity. Weighing only 4½ lb. and measuring 33½ in. long, the N 533 can be easily carried in the hand or slung from the body on a comfortable shoulder strap. The sensitivity of the instrument is such that radiation from 2–3 micrograms of radium at a distance of one metre gives a count of 120–150 pulses per second.

Award for Fruit Research

The Jones-Bateman Cup of the Royal Horticultural Society is offered triennially for original research in fruit culture. Past holders of the cup are Mr. M. B. Crane, F.R.S., Dr. W. A. Roach, Dr. W. S. Rogers and Dr. A. Beryl Beakbane. The cup is again offered this year and candidates must submit accounts of their work by October 31. Full details can be obtained from the R.H.S., Vincent Square, S.W.1.

To encourage the writing of articles for the technical and scientific press, the Radio Industry Council awards some six prizes every year. The photograph shows this year's prizewinners, who are (left to right): *A. W. KEEN, A. D. BRISBANE, A. H. BECK, MISS JOYCE E. SEABORN, H. M. DAVIS, J. R. POLLARD* and *G. G. GOURIET.*

A Pioneer Producer of Microscopic Stains

The Hinchley Medal of the British Association of Chemists for 1953 was presented to G. T. GURR, F.R.I.C., on March 19. The presentation was made by the association's senior vice-president, DR. HERBERT LEVINSTEIN, and was followed by an address by Mr. Gurr, who described how he took up the business of selling microscopical stains. During World War I he supplied stains to the medical services of the Army and Navy, and afterwards he started the firm, which is now well known all over the world, with a capital of only £594—the capital involved now is 60–70 times greater! In the early days there was a strong pro-German prejudice among scientists and medical men to overcome: "If a slide was stained poorly the technician would be asked what brand of stain he was using, and if the answer was 'German' he would be told to try again, but if 'British' he would be told to get 'German'." In most cases, said Mr. Gurr, it was not the dye that was wrong, but some other factor.

The first firm to produce microscopic stains was Dr. G. Grübler & Co., of Leipzig, which started in 1880; Hollborn & Söhne was an offshoot of that firm. Most British laboratories were using Grübler's stains in 1914, and this applied even to stains such as Leishman's, developed by a British medical officer in 1901 for staining malaria germs. Mr. Gurr told how he succeeded in providing these stains during World War I.

Besides their well-established uses in medical, zoological and botanical work, stains figure in many branches of industrial research (e.g. in connexion with timber, wool and cotton) and industrial process control. Mr. Gurr concluded his lecture by enumerating some of the principles of histo-chemistry upon which differential staining techniques depend, adding that histo-chemistry has a middle position between histology and biochemistry with a slight resemblance to microanalysis; although its development is young, its roots go down to the starch iodine reaction and the prussian blue test for iron.

The Oldest Life

The note in our last issue ("The Oldest Life," DISCOVERY, April 1954, pp. 140–142) reporting the discovery of fossil plants in rocks of about 2000 million years old, we mentioned that Prof. Arthur Holmes, of Edinburgh University, believes that plant life has flourished on the earth for at least 2700 million years.

Prof. Holmes has now published in *Nature* (April 3, 1954, p. 612) the evidence that justifies that opinion. The particular specimens of plant life to which he gives that age are algae present in rocks of the Bulawayan System. These fossils were first noticed by Dr. A. M. Macgregor in 1935, in studying graphitic limestone 33 miles N.N.E. of Bulawayo.

This limestone sediment is cut by pegmatite intrusions which are older than the limestone. The dating of the pegmatite specimens has been based on monazite which they contain. Samples of monazite from different intrusions were sent to the D.S.I.R.'s Chemical Research Laboratory, which carried out estimations of lead-, thorium- and uranium-content, and also prepared specimens of pure lead iodide from the samples. These specimens were forwarded to the laboratory of PROF. ALFRED O. NIER at Minnesota University, where they were analysed by mass spectrometer to find out the proportions of the four lead isotopes (Pb 204, 206, 207 and 208) which were present.

Prof. Holmes calculated the age of the pegmatite from these two sets of analyses and arrives at a figure of about 2640 ± 40 million years. He concludes his *Nature* communication by saying that this age determination provides "indubitable evidence that life has existed for at least 2600 million years and probably for considerably longer than 2700 million years".

A Teaching Film about Radio Valves

A film giving a clear description of the way radio valves are made has been produced by Mullard. Entitled *The Manufacture of Radio Valves*, this was designed for showing to engineers, technicians and students. It runs for 25 minutes, and can be borrowed from the Mullard Educational Service (Century House, Shaftesbury Avenue, London, W.C.2).

Radiochemical Centre Increases Isotope Production

The new buildings of the Radiochemical Centre at Amersham, opened by SIR HENRY DALE on April 8, are the first in Britain that have been specially designed to accommodate isotope-production processes. Hitherto the very substantial quantities of radioactive isotopes which have come from Harwell and Amersham have mostly been produced in simple laboratory apparatus, housed in general purpose buildings. The demand has now increased so far that for several of the more important isotopes it has become necessary to construct individual chemical plants, completely screened and remotely operated, and to install them in buildings designed for the purpose.

The building scheme provides for eight buildings, four of which have so far been erected. In one there is the separation of fission products; in another, the production of radioactive iodine, phosphorus, and other isotopes. Another is used as a dispensary for radioactive solutions, and the fourth is for biological processes.

The chemical development and the production of the plants involved have been a co-operative effort between the chemists in charge, Dr. C. C. Evans and Mr. P. E. Carter, and the resident engineer, Mr. W. R. Tribe. Most of the equipment has been made in the Radiochemical Centre's workshops.

According to *Bulletin of the Atomic Scientists*, Britain is today producing a bigger range of isotopes than the U.S.A.

F.B.I. Investigates shortage of Science Teachers

The Federation of British Industries has set up a committee with the aim not only of improving the supply of science teachers to the schools in the difficult years, 1955 to 1960, but of seeking a permanent solution. The chairman of the committee is DR. PERCY DUNSHEATH, and the other members (each of whom serves solely in a personal capacity) are as follows:

REPRESENTING SCHOOL INTERESTS.—Miss M. J. Bishop, Godolphin and Latymer School, Hammersmith; Mr. W. R. Hecker, St. Dunstan's College, London; Mr. Ian Hepburn, Oundle School; Dr. W. G. Humphrey, The Leys School, Cambridge; Miss K. E. Parks, North London Collegiate School.

UNIVERSITIES.—Professor J. W. Cook, F.R.S., Glasgow; Mr. J. G. W. Davies, secretary, Cambridge University Appointments Board; Professor E. Giffen, London.

TECHNICAL COLLEGES.—Dr. G. E. Watts, Brighton.

INDUSTRY.—Mr. A. D. Bonham-Carter, Unilever Ltd.; Dr. W. S. Bristowe, Imperial Chemical Industries Ltd.; Mr. G. S. C. Lucas, British Thomson-Houston Co. Ltd.; Mr. J. A. Oriel, Shell Petroleum Co. Ltd.; Mr. L. A. Pilkington, Pilkington Bros., Ltd.; Mr. Madron Seligman, the A.P.V. Company Ltd.; Mr. A. H. Wilson, F.R.S., Courtaulds Ltd.

GOVERNMENT AND NATIONALISED INDUSTRY.—Dr. B. K. Blount, Department of Scientific and Industrial Research; Sir George Gater, chairman of the Technical Personnel Committee, Ministry of Labour; Mr. M. Milne-Watson, chairman, North Thames Gas Board.

Sir Martin Roseveare and Mr. A. A. Part, of the Ministry of Education, have been invited to attend meetings of the committee as observers.

The Earliest Detergents

The early history of detergent substances used in Babylonia was the subject of an interesting paper to the meeting of the American Chemical Society held in Kansas City (March 23–April 1). The author was MARTIN LEVEY, of Pennsylvania State University.

In ancient Babylonia, the most commonly used detergents for clothing and bodily ablutions were soda and potash derived almost entirely from the ash of plants rich in alkali. These botanical sources were abundant in the Near East. Other types of washing substances, such as alum and various types of clays and earths, were also utilised to a much lesser extent.

Philological evidence, unfortunately, reveals no clues to the origin of soap. However, the oldest references to the preparation of soap are to be found in the ancient Near Eastern literature. From Egypt, the Berlin papyrus (*c.* 1350 B.C.) and the Ebers papyrus (*c.* 1550 B.C.), both medical documents, indicate that the preparation of soap and plasters was then known to the medical fraternity. The preparation of soap is also to be found in a number of medical tablets written in the Babylonian cuneiform reaching back to the third millennium B.C. In the first millennium B.C., we have records of the compounding of metallic soap, resin soap, sulphur ointment, and soap as well as carbonate soaps. These are to be found in the Akkadian literature.

Sumerian tablets, both medical and nonmedical, provide us with the most ancient known methods for the preparation of soap. These date back to the Gudean period and thereabouts (c. 2250 B.C.) antedating the Egyptian works by about 700 years. One recipe, rare for its quantitative character, specifies 1 qa of oil and $5\frac{1}{2}$ qa of alkali, the latter probably in the form of ash. Another recipe to wash wool included among other substances oil, dates, and wood ash. In a Sumerian pharmacological tablet, we have the prescription for a medicated soap; *Salicornia fruticosa* (an alkali plant), salt, cassia oil, powdered asafoetida, and other substances are kneaded together. Fine beer and boiling water are then poured thereon. This solution is then sprinkled upon the patient.

True soaps are not generally known in antiquity. However, some of the recipes reveal the use of salt, probably as a 'salting out' agent. Thus, almost all ancient soaps were similar to the present-day cold or semi-boiled types in which the glycerol and water remain in the product mixture.

Chemistry, Foodstuffs and Crop Plants

The 'staling' of bread and its correlation with starch—and gluten—content was discussed by W. G. BECHTEL. For his experiments he used bread that was made with wheat starch and gluten instead of flour. When the protein content of the starch-gluten mixture was between 11 and 17%, the breads were indistinguishable from commercial bread. Sensory perception tests of staling of such breads with protein content covering the above range were made during a six-day storage period. During the first three days there was no significant difference in staling rates of breads of different gluten contents. Between the third and sixth day, rate of staling decreased markedly as gluten content increased. Deterioration of starch appears to be the major cause of bread staling during the first two or three days. After longer storage, crumb moisture and crumb texture appear to be of major importance.

Scientific concern over the increasing use of highly toxic chemicals in agriculture was expressed by the large number of papers relevant to this topic which were delivered to this A.C.S. meeting.

Three scientists working in the Pharmacology Department of the University of California School of Medicine reported on toxicity studies they had made in laboratory animals and clinical observations on human patients.

They found that among organophosphorus compounds the greatest biologic activity is found in the phosphates and phosphonates. The toxicity is due to one or more of the following known effects: cholinesterase inhibition, selective degeneration of the nervous system, stimulation and depression of the central nervous system, and irritation of exposed surface tissue.

No evidence of anticholinesterase activity has been observed in animals among the phosphinates, phosphine oxides, phosphites, or phosphonites. Among the phosphates and phosphonates, however, cholinesterase inhibition is demonstrable in animals and man. Phosphates were responsible for one-third (303) of the cases of occupational disease caused by agricultural chemicals in California during 1951 and 1952. Deaths followed ingestion, but not occupational exposure.

So far, only three of the compounds have been shown to cause nervous degeneration: triorthotolylphosphate diisopropylfluorophosphate and bis (mono-isopropylamino) fluorophosphate. Two of these have caused long-lasting paralysis in man; all three inhibit cholinesterase activity. (These extremely toxic compounds fall, of course, into the same category as the so-called military 'nerve gases'.)

Organic phosphonates and phosphites, which have few industrial uses, are apparently not highly toxic. According to animal tests, they cause depression of the central nervous system, principally, and their irritating properties are increased by incomplete substitution of the available hydrogen by alkyl or aryl radicals. Alkyl phosphines are undoubtedly very toxic, but there is insufficient knowledge of this group to justify definite statements concerning structure-action relationships.

Another paper stressed the need for chemists and pharmacologists to be consulted throughout every programme that aims at the development of a new insecticidal material. Since the final evaluation of safety for a pesticide on food crops is based on the residue level at harvest, the formulation must bring into accord the entomological, economic and toxicological objectives.

Weed-killing chemicals were also discussed, and it was stated that one of the major unsolved problems that arise in the spraying of crops with these substances is the control of drift.

Appointments

MR. JAMES HODGE, M.A., A.M.I.MECH.E., A.F.R.AE.S., a gas turbine expert and senior consultant of Power Jets (Research and Development) Ltd., is lecturing at Columbia University, New York, as visiting professor in gas turbines. One of Sir Frank Whittle's war-time team engaged on jet engine design, he has been associated with Power Jets School of Gas Turbine Technology (the only one of its kind in the world) since its inception in 1944, and he lectures there regularly. Mr. Hodge graduated in mechanical sciences at Cambridge in 1941.

* * *

REAR ADMIRAL (E) ROBERT COBB has joined the staff of the British Council's Science Department with special reference to the Council's activities in engineering.

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THE retirement of Mr. G. M. WRIGHT from his position as engineer-in-chief of Marconi's Wireless Telegraph Co., Ltd., has led to several changes among the senior technical appointments in the firm. His successor is Mr. B. N. MACLARTY, whose deputy will be Mr. R. J. KEMP.

Dr. E. EASTWOOD replaces Mr. Kemp as chief at the Company's Research Establishment at Great Baddow.

Mr. R. J. Kemp joined the company in 1917, and from 1930 to 1939 he was engineer-in-charge of Television Research. During World War II he was responsible for Air Ministry Special Research at the Great Baddow Research Establishment.

Dr. E. Eastwood is a physicist who has been engaged primarily in research in the field of molecular constitution and in the application of radar techniques to the investigation of celestial noise and the detection of meteors. During World War II his attention was directed to radio work with the R.A.F. He joined the English Electric Company, Ltd., in 1946 to take charge of their extensive Radiation Laboratory. In 1948 he was transferred to the Marconi Company as Deputy Chief of Research at the Great Baddow Establishment of which he now assumes control.

* * *

MR. A. G. PEACOCK, B.Sc., A.R.I.C., A.Inst.P., has resigned his position as secretary of the Scientific Instrument Manufacturers' Association and joined the board of Mervyn Instruments, St. John's, Woking, Surrey. Mr. Peacock is perhaps best known as the Hon. Exhibition Secretary of the Physical Society, and as a protagonist for increased publicity for British instruments is a well-known figure at exhibitions both in this country and abroad.

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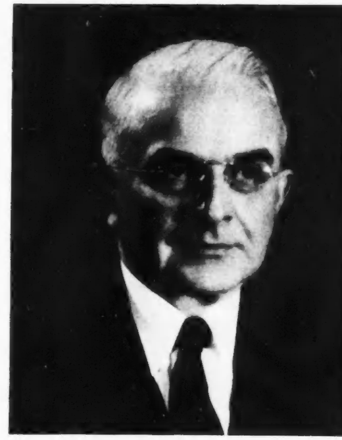
THE Ministry of Supply has made the following appointments:



Dr. Philip Vincent Cardon, newly elected Director-General of the Food and Agriculture Organisation of the United Nations. A graduate of the University of California, he joined the U.S. Department of Agriculture in 1909, and went to Washington in 1935 as principal agronomist in charge of forage crops and diseases. He became Assistant Research Administrator in 1942, and Administrator in 1945.

BRIGADIER J. D. HAIG becomes Director of Electronics Research and Development (Defence).

MR. H. W. FORSHAW has been appointed to succeed Dr. G. W. Sutton as Chief Superintendent, Signals Research and Development Establishment, Christchurch. Dr. Sutton left the public service on March 31. Mr. Forshaw has been assistant director in the Directorate of Electronics Research and Development since 1947.

* * *

MR. W. H. TAYLOR, B.Sc., A.M.I.E.E., has joined the General Electric Co., Ltd., as controller of education and personnel services. A graduate of King's College, London, he served in the R.A.O.C. and the R.E.M.E. during the war. In 1947 Mr. Taylor became education officer on the staff of the Institution of Electrical Engineers.

* * *

DR. B. P. DUDDING, vice-chairman of the Advisory Scientific Panel of the G.E.C. Research Laboratories, has been honoured by the Italian Government (in recognition of his services to the Italian glass industry) and so becomes a member of the "Ordine al Merito della Repubblica Italiana". A fellow of the Institute of Physics since 1921, Dr. Dudding became honorary secretary of that institute in 1946. He was president of the International Commission on Glass in July 1953, and is a Founder Fellow of the Society of Glass Technology.

Insecticidal Seed Dressing

GAMMEXANE, which is a powerful and persistent insecticide in widespread use, is now available in the form of a dry seed dressing to protect brassicas against flea beetle. This new preparation, called *Gammasan*, is economical, and the cost of applying it to brassica seed works out at about six shillings per acre for seed planted at the rate of 4 lb. per acre. It also protects carrots against carrot fly: early-sown carrots are protected up to four to five months and the late sowing for up to two to three months.

'Gammasan' contains 'Gammexane' gamma BHC and thiram fungicide; the fungicide gives a measure of protection against foot rots. Seedlings from treated seed emerge more quickly and therefore there is less competition from weeds. The rows of seedlings are clearly defined and so inter-row cultivation can be carried out at an early stage.

For British farmers this development is important, as brassica crops cover about 1¼ million acres and are worth £60 million.

The damage done by the flea beetle is over £5 million a year—over £1 million of turnips and swedes alone are probably lost.

Coccidiosis and the Deep-Litter System

The deep-litter system of poultry keeping is scientifically interesting for a variety of reasons. For example, the fermentation processes occurring in the litter is a source of valuable vitamins, including vitamin B_{12}. Now a research worker has suggested that the method keeps coccidiosis in check. Addressing a recent NAAS conference, Dr. C. Horton-Smith, parasitologist to the Animal Health Trust, said that though the temperature in ordinary unheaped deep litter was too low to kill the oocysts of the coccidia parasite, the ammonia content was lethal to these organisms. In well-managed litter the number of oocysts was low. He thought that this would lead to the fowls developing a resistance to the disease. It has been shown experimentally that fowls reared on deep litter can survive large doses of coccidia, which implies that their resistance to coccidiosis has been increased. Dr. Horton-Smith said there was little information about the fate of other parasitic organisms in a population of chickens kept on deep litter, commenting "What is poison to the coccidia may be food to the host of other undesirable organisms—we simply do not know."

Potato breeding in America

High-quality, uniform, easy-peeling potatoes for the housewife, and disease- and insect-resistant, high-yielding potatoes for the farmer are among benefits accruing from 43 years of breeding research carried on by the U.S. Department of Agriculture and reported recently at the annual meeting of the American Association for the Advancement of Science.

In a paper delivered to the Association's agriculture section, Dr. F. J. Stevenson, of the U.S.D.A. research service, reviewed the part that potato breeding has played in boosting national average per acre potato yields—from 94 bushels per acre in 1910, when the potato-breeding research was started, to nearly 250 bushels today. Other factors, such as insect control, have also been important in this big advance. It would be safe to predict, he said, that the national average yield per acre may go as high as 300 or more bushels by 1973.

About 40 new potato varieties have been distributed to American growers since 1932, Dr. Stevenson reported. Of these, acreage of 23 varieties was listed in 1952 for certification in the production of seed stock for planting by farmers. Notable breeding achievements have been made in combating potato diseases —an important factor in both yield and quality, added this American geneticist.

A New Wide-angle Telescope

A telescope of a new design which will greatly assist astronomers has been unveiled at the observatory of a small American university near Nashville, Tennessee. It was designed by Dr. James Baker, of Harvard.

The new device is called a Baker reflector-corrector telescope. It consists of a mirror arrangement which permits a wide angle of vision to be photographed through the telescope. The 100-inch Schmidt telescope—at Mount Palomar observatory in California—is able to make similar wide-angle studies of the skies, but requires special curved photographic plates. Dr. Baker's design permits regular flat negatives to be exposed.

In addition, the new telescope designed by Dr. Baker for Vanderbilt University can be used as a conventional telescope by swinging the photographic apparatus away from the view-piece.

Towards an Automatic Factory: Diffraction gratings in industry

For some time the National Physical Laboratory has been developing a new method, suggested by Sir Thomas Merton, for making diffraction gratings. Although primarily intended as components of spectroscopes for analysing radiation, the 'Merton-N.P.L.' gratings are finding a very useful application in industry. They can be used for precise measurement of length and the control of machine tools. For these purposes long accurate transparent gratings are needed. By the new process they can be produced quite cheaply.

If two of these gratings are placed one upon the other with their rulings inclined at a small angle dark lines or fringes are produced. They run at right angles to the rulings, and resemble the 'moiré' effect of watered silk. If, now, one of the gratings is kept at rest and the other is moved very slowly in the direction of the fringes, the fringes are found to move also but at a greatly magnified rate. The number of them which pass across the field of view can readily be counted by a photocell and electronic counter. This method lends itself to very accurate and rapid measurement, for when gratings ruled with 10,000 grooves per inch are moved in this way the fringe counter will record the movement in ten-thousandths of an inch.

An industrial firm is collaborating with the Light Division of the N.P.L. in applying this method to the control of machine tools, such as jig borers, and are working out a further application of it to the automatic control of machines. When this work is completed it will be possible for elaborate machining operations to be performed from instructions stored up in a tape machine. The truly automatic factory will then be in sight.

Control of Red Spider Mite

Since 1944 the Pettar Society of Winter Wash Manufacturers, the Associated Fruit Growers of Essex, Ltd. (Ace Growers) and the Agricultural Research Council have jointly organised and financed investigations into the commercial control of the fruit tree red spider mite, one of Britain's most serious orchard pests.

The first stage of the investigations was devoted to the trial of winter washes, but these by themselves were found not to give a sufficient degree of control. Since 1949 the investigations have been concentrated on the use of summer acaricides and ovicides, including derris, parathion, diphenyl sulphone (DPS), chlorphenyl benzenesulphonate (CPBS) and chlorphenyl chlorbenzenesulphonate (CPCBS). It has been found possible to obtain effective control of the red spider mite by a single application of DPS, CPBS, or CPCBS as an ovicide when applied with a suitable acaricide. By observing proper precautions, with due regard to variety, spray damage to trees and fruit can be eliminated or reduced to a minimum.

Stirling's Rock-Wool Factory

On March 5, the Earl of Home, Minister of State for Scotland, performed the opening ceremony of the new rock-wool factory at Stirling which provides a new industry for Britain in the production of a long-fibre rock wool. All the raw materials are available in large quantities in Scotland and have never hitherto been used for this type of production. The main components of the mix to produce the rock wool are *dolomite rock* from Duror, on the south side of Loch Linnhe, in Argyll, and *siliceous clay* from Stirlingshire.

'Rocksil', as the new product is called by reason of its fine silken appearance, is an inexpensive form of heat-, cold- and sound-insulation material.

LETTERS TO THE EDITOR

Science and the Press

Sir,

The letter by Professor F. E. Simon in DISCOVERY of April 1954 on the above subject raises two issues about which opinions have been expressed so frequently by scientists that a general comment on them might help to clear matters.

(1) Prof. Simon complains that reporters too frequently pick out only a few items—"those which can give a sensational headline". He cites as an example the reporting of one item only which took *three minutes* to relate in a lecture of his which lasted *one hour*. Of course, this is very common practice among newspapers, and is not confined to science lectures. The reasons are obvious. The chief one is lack of space. Moreover, a scientist must realise that when he is reported in a general newspaper (as opposed to a scientific or other learned journal) he has to take his place among all other facets of social life—politics, the arts, the theatre, music, the law courts, general news and so forth. Therefore it must inevitably be left to the editor to decide what to select. (In parenthesis, may I point out that reporters frequently submit much longer accounts to their editors than actually appear in print—again for the same reasons.) It must be left to the editor to select what shall be published, and he is not only governed by many strong factors beyond his own control, but is also influenced by his own knowledge of what the public will, or wishes to, read—knowledge gained from editorial experience. While I am writing this, Mr. Butler is delivering his Budget speech in the House. I trust the national newspapers tomorrow will, in their wisdom, tell us laymen what we wish to know, and leave the details to *Hansard* and the specialist financial and economics journals. I do not think Prof. Simon's claim in this connexion that the meagre selection is made in order to give "sensational headlines" is justified in general; "sensational headlines" appear more often on newspaper vendors' placards than in the newspapers themselves.

(2) The question of the right of editors to change articles written at their request is not to be dismissed so categorically as Prof. Simon would clearly wish. That changes and reductions, perhaps even additions, should be made by an editor and then published over an author's name without his sanction seems, on the face of it, undesirable. And indeed so it is to such an extent that by far the majority of editors prefer not to do it. Weekly journals and other periodicals are able to obviate this by sending proofs to the authors (in my own case I even received a proof of an article written by me which was to be published in a national daily newspaper). But in the case of daily newspapers, and especially those of a national character, there is always the problem of time and space. Frequently time will not allow the nicest courtesies of editorial etiquette, and often authors do not seem to appreciate the editor's efforts at getting a quart into a pint cup.

There can be few of our more active authors who have not had the experience of reading their commissioned articles in newspapers and finding changes which do not appeal to them—cuts, rearrangements, inserted sub-heads, etc. Sometimes such an author may be quite justified in his anger at the behaviour of the editorial blue pencil, more often, however, the author would do well to cultivate a sense of proportion and ask himself: have the changes made all that much difference to the tone or even the theme of the article? (It may never occur to him that they may have improved it.) After all, the editor knows a thing or two, and does not wield the blue pencil just for the fun of the thing. I view with concern Prof. Simon's experience of having a series of articles going "to print unchanged", for it savours of an 'all or none' rather dictatorial policy. I would rather an author showed sympathy with his editor, recognised that there are aspects of publishing about which the latter is more authoritative than the former, and then work in an atmosphere of give and take. If as a result an article appears over an author's name in not quite the form in which it was originally written, then it is by and large due to force of circumstances. I am certain that to adopt the attitude towards the general and newspaper Press that it *must* publish what is written, or at least consult an author about any proposed change (especially when time and space are the main bugbears) is at least kicking against the pricks, if not leading to the very thing one would wish to eliminate, that is, unnecessary argument and possible unhappy relations between the scientist and the Press.

L. J. F. BRIMBLE.

The Athenaeum,
London, S.W.1.

Ship Stabilisation

Sir,

I was particularly interested in the article by F. M. Beatty in DISCOVERY, November 1953 issue on Charles Stanhope, and noted for the first time that the Earl of Stanhope had attempted, by attaching four hinged sets of gills at the four quarters of a ship, to make the ship ride more steadily through heavy seas as far back as 1807.

The article, however, is somewhat misleading in suggesting that this idea was the immediate forerunner of the system of stabilisation used in the modern P. & O. liner, the *S.S. Chusan*. This system which uses the idea of an oscillating fin was first suggested in a patent (No. 19516) granted to my father Andrew Wilson, F.I.C., over 60 years ago, while he was science master at Stirling High School. As a boy of ten I was a passenger in a small boat fitted with these oscillating fins when trials were carried out on the River Forth. In addition small models, in the Kelvin tradition, were made of the apparatus, and shown to various ship owners in 1890 but without success as far as the adoption was concerned.

I am happy to state, however, that Messrs. Brown Bros., of Edinburgh, the makers of the Denny Brown Stabilisation Gear used on the *Chusan* (and a very much improved form of oscillating fin which can be withdrawn into the ship's hull when not required) have acknowledged the priority of my father's invention in a letter in reply to Mr. John Robertson, librarian, Stirling Public Library, while the nautical magazine, the *Trident*, refers to the original Andrew Wilson patent in their article on the *Chusan* in their August issue of 1950. Other papers, such as the *Stirling Journal and Advertiser* of November 30, 1950, and also the *Stirling Observer*, carried articles on the subject at that time.

Yours faithfully,
JOHN M. F. WILSON.

4516 Eva Avenue,
Victoria, B.C., Canada.

"Science Survey" and Schoolboys' Bedtime

Sir,

The people who would most enjoy and profit from the excellent 'Science Survey' talks on the wireless are the senior science pupils in our schools. But the B.B.C. broadcast them late on Thursday evenings—when these pupils are in bed; and they are repeated early on Saturday mornings, when they are at work. To make matters worse, these talks are transmitted on the Home Programme—which is almost inaudible here. I wonder whether you could suggest to the B.B.C. either that they alter the time of these broadcasts, or that they publish the text in *The Listener*? They are too good to miss.

Yours faithfully,
A. J. P. ANDREWS.

Cameron,
The Avenue, Sherborne,
Dorset.

THE BOOKSHELF

Fishery Science: Its Methods and Applications

By George A. Rounsefell and W. Harry Everhart (*New York, John Wiley; London, Chapman & Hall, 1953, 444 pp., 60s.*)

There can be no doubt that the authors have written a most valuable work, which will have an extremely wide appeal. Nothing at all similar has been published previously, and this book will be welcomed by the expert, the student and the layman alike. Anyone who is interested in fish, marine or freshwater, or who has cast a fly, can hardly fail to find much fascinating information in it.

The main theme is 'the management of fisheries', or the application of science to ensuring the optimum yield or sport from any stretch of water. To the reader in Britain it may come as something of a surprise to realise how far advanced this subject has become on the other side of the Atlantic. But then, the visitor to America is inevitably surprised, if not shocked, by the close control of his rod which is applied through State or local authority. It is common there to be restricted to two or three fish per rod per day, and woe betide the enthusiast who fails to acquire his licence before indulging in this limited privilege. However, in the States, 'conservation' of this sort is generally accepted as a necessity. To the American, fishing is a popular recreation, and a vast number of enthusiasts enjoy the excellent sport provided by the lakes and streams. Without control, the slaughter of game fish would far exceed the growth of wild populations; in 1951, we are told, there were 16,000,000 licensed anglers in the U.S.A.

The authors, however, do not so much stress the fish's need for legal assistance in its struggle for survival. Rather, they consider the fish population as an entity and argue out on a scientific basis how its welfare can be best ensured by practical management. In this respect they deal with both sport and commercial fisheries.

The text covers the subject comprehensively. After a preamble headed "How do we produce Knowledge?" which may seem somewhat trite to the scientist, there are five excellent chapters on fish populations, their fluctuations and methods of estimating them. Then follow many practical details on the construction and management of fish-ponds; a well-illustrated account of the varied types of commercial fishing gear; chapters on the protection of stocks by the provision of fish-ways, screens and racks, and by the avoidance or control of pollution. Next are discussed methods of improving the environment by using dams and deflectors in streams, by using artificial fertilisers to stimulate production in the food chain, and by removing undesirable competitors to the stock both by chemical and electrical means.

The latter part of the book tends more to the scientific or experimental side. It deals with the 'tagging' and marking of fish, with methods of determining age and growth, and finally with management techniques. In conclusion, there is a short review of current problems, followed by an international—if not comprehensive—list of fishery journals, and a useful glossary and index.

In all, it is an excellent account, and on one point only can serious criticism be levelled. Time and time again the reader may feel that the references cited in the text are not well balanced. Many of what may seem to him to be the more interesting biological points and experiments are mentioned briefly, with no guidance as to where more detail may be found. For instance, although the experimental transplantation of marked plaice in the North Sea is cited as an example twice, the reader is given no clue as to where he may read more about these classic trials. Again, although mention is made of the pioneer Scottish work on the artificial fertilisation of a sea-loch, no reference is given. Many other similar cases might be listed. But, on the other hand, the reader is referred to Whiteleather and Brown (1945) for authoritative evidence that a hand line—". . . a single line with one or several baited hooks"—can be used successfully to catch fish in the Caribbean; and again to the original paper for a recommendation that a five-man party may be satisfactory for a fishery survey, details of which are not specified.

The Mountain World 1953

Edited by Marcel Kurz (*London, Allen & Unwin, 1953, 220 pp., 25s.*)

This is the first of an annual series published in three languages which the Swiss Foundation for Alpine Research is organising. The greater part of the book is devoted to accounts of the 1952 Swiss Everest Expedition, the first to attack the mountain from the south, so paving the way for the British victory in June 1953. Scientifically one of the most interesting chapters is that by Dr. E. Wyss-Dunant on problems of acclimatisation. His conviction about the importance of vitamins to the climber (p. 115) is worth consideration by physiologists; at high altitudes "vitamin starvation is intense; it shows up in an overwhelming desire for fruits and vegetables, despite the consumption of synthetic vitamins", a point which may be challenged perhaps, but which cannot be ignored.

Microwave Lenses

By J. Browne (*London, Methuen, 1953, 128 pp., 60 figs., 8s. 6d.*)

This monograph is a concise compilation of the articles and papers by Mr. Brown which have appeared in various periodicals, coupled with facts derived from recent research on artificial dielectrics. The types of lenses dealt with are solid dielectric, metallic delay dielectric, metal-plate and rodded dielectric, path length lenses, and non-homogeneous lenses, and one chapter is devoted to the problems of wide-angle scanning. Each type of lens is considered theoretically and, where possible, the measured performance and the effects of dimensional errors are also given.

The lenses described are all designed to produce a plane wavefront from a point source of radiation, which is the primary requirement for radar systems. Obviously, by placing two lenses back-to-back, it is possible to focus the radiation to a point, but very little mention is made of lenses which will give any other specified field pattern. This may be an unreasonable criticism to make, but to deal adequately with methods of producing unusual radiation patterns would probably require a book somewhat larger than a Methuen monograph

For those who wish to obtain data in order to manufacture a particular type of lens, the graphs are nearly all too small (and occasionally not too clear) to allow of reasonably accurate interpolation, and these readers must either calculate the appropriate figures or comfort themselves with the knowledge that an error of $\lambda/4$ can usually be tolerated in dimensions. On the whole, the theoretical analyses of lens performances are extremely good, and the practical considerations make a brave effort to reach the same high standard.

Physiology of Seeds: An Introduction to the Experimental Study of Seed and Germination Problems

By the late William Crocker and Lela V. Barton (*Waltham, Mass., Chronica Botanica: London, Wm. Dawson, 1953, 267 pp., 26 tables, \$6.50 or 52s.*)

Seeds are tiny plants packed for transportation. Upon them ultimately rests the continuance of agriculture and civilisation. This book is therefore welcome; moreover, knowledge of seed physiology and chemistry helps to provide the necessary background for understanding problems confronting the seedsman. At the same time, this phase in the flowering plant's life-cycle is itself interesting to biologists studying the behaviour of living organisms.

The scope of this useful book is best illustrated by its chapter headings. There are initial chapters on seed anatomy and production, followed by surveys of chemical composition, water relations and respiration, factors affecting germination, dormancy, life span and storage, metabolic and energy changes in

seed development and germination, vernalisation and seed transmission of disease. There is also a chapter of embryo culture, which is of increasing importance for obtaining difficult interspecific hybrids.

The publishers claim there are 1100 references; these are grouped after each chapter, which is rather inconvenient and leads to wasteful repetition. Although these cover a wide range of sources, for some mysterious reason the authors have omitted references to the work of Sir Edward Salisbury, one of the leading British students of seeds.

GORDON HASKELL

Isotopic Tracers in Biochemistry and Physiology

By Jacob Sacks (*London, McGraw-Hill Book Co., 1953, 383 pp., 68s.*)

The application of isotope tracer techniques to the problems of biochemistry has grown enormously in recent years. In his book on the subject Prof. Sacks has attempted to meet the needs of specialisation consequent on this growth by reviewing biochemical problems which have been attacked by tracer techniques at the expense of discussing the techniques themselves. There are, however, introductory chapters (pp. 1–56) on the principles of preparation and assay of stable and radioactive isotopes. There is evidence that the author was on unfamiliar ground here. His definition of the electron-volt on p. 18 may amuse the physicist but confuse the student. On p. 46 the author claims that a net count of 10,000 collected "within a few minutes" is accurate to within one per cent. This is untrue. These and similar remarks tend to vitiate the value of the book as suitable reading for students. On pp. 160–61 the author suggests that "paper chromatography . . . is likely to prove of only limited value for tracer experiments". Few biochemists would accept that today. The combined techniques have already proved to be one of the most powerful research tools introduced into biochemistry. Almost all the spectacular and important work on photo-synthesis by Prof. Calvin's team in California was done by these techniques as Prof. Sacks himself indicates (but briefly) in his final chapter. Other chapters (pp. 63 *et seq.*) review examples of the use of tracers in studying ion transport mechanisms, carbohydrate metabolism with particular reference to phosphorylated intermediates, protein, nucleic acid, fat metabolism, etc., and there is a chapter on the use of radio-iodine in thyroid studies. Many of the examples are discussed so briefly as to be little more than abstracts. For the biochemist already familiar with tracer techniques these chapters do, however, make fascinating reading. They illustrate clearly how tracer experiments have quietly revolutionised the biochemical picture of chemical reactions *in vivo* so that almost all the chemical constituents of living tissues are seen to be in a remarkably fluid state of degradation and synthesis. The book is expensive. It is not recommended as a student or research text but as salutary reading for the biochemist familiar with tracer methodology.

F.P.W.W.

The Elements of Navigation

By Charles H. Cotter (*London, Pitman, 1953, 535 pp. 40s.*)

This is a textbook of navigation. It deals at length with the fundamentals of navigation when there are landmarks—coastal navigation, and when there are not—celestial navigation. The latter, especially when worked out fundamentally, is usually taken as more difficult than the former, largely because of the mathematics involved, and the author therefore takes care in solving specimen problems and expounding the basic methods used in getting a position from observations of celestial bodies. Men training to be professional navigators—airmen as well as mariners—are thoroughly and lucidly served by Mr. Cotter in this textbook, which would, I think, have to be used with an instructor to explain some of the jargon, such as, for

example, the operation of 'entering' a nautical table, and what is meant by the 'argument' of such a table. Modern amateur navigators—chiefly yachtsmen—could use this book to help them to fill in the bare outline they get when they learn simplified methods. There is a full account of the gyro compass. Clear diagrams assist the text all the way.

The author is rather detached. He has paid, designedly I suppose, little attention to the needs of the amateur and extreme beginner. For instance, many versions of navigation tables could have been mentioned—the wide range of these is a puzzle to the beginner, who wonders at first if he is expected to own a library. There is no space here to catalogue the tables not referred to, but one omission surely is unfortunate. It is the American publication H.O.214, tables of computed altitude and azimuth. These tables simplify the calculations considerably and are accurate enough to be approved by the Royal Navy and the United States Navy. They are also being used in the celestial navigation taught at the Little Ship Club. If the author chooses to repair the omissions in a second edition, his book will then be, what it just fails to be now, a standard fundamental and comprehensive text.

In one respect, however, he almost atones for his omissions. It is his inclusion of all the up-to-date radio methods of navigation, now tending to replace sextants and calculations in big ships in all positions except those in the remote parts of the oceans. The four now in regular use are Consol, Gee, Loran and Decca. All are given some exposition by Mr. Cotter, who completes his book with a short account of radar, an account that could with advantage be expanded in a future edition. C. L. BOLTZ

Galileo Galilei: Dialogue Concerning the Two Chief World Systems. Translated by Stillman Drake (*U.S.A., University of California Press; London, Cambridge University Press, 1953, 496 pp., 75s.*)

"We love," wrote Macaulay in 1831, "to read the great productions of the human mind as they were written. We have this feeling even about scientific treatises, although we know that the sciences are always in a state of progression." To add point to his words, he cites Adam Smith's *Wealth of Nations* and Newton's *Principia*; he might with equal cogency have adduced the writing of Galileo.

The famous *Dialogue concerning the Two Chief World Systems*, the publication of which in 1632 resulted in Galileo's trial and condemnation by the Inquisition, now appears in an excellent English translation, the first for nearly three hundred years. Prefixed to this edition is a long foreword in German with English rendering interleaved, by Einstein, who declares the book to be "a mine of information for anyone interested in the cultural history of the Western world and its influence upon economic and political development."

Written originally in colloquial Italian instead of in the Latin which was then usual for works of learning, the *Dialogue* reveals its author's personality on every page. The numerous attacks on the authority of Aristotle are often humorously expressed, and the character Simplicio, who has the task of defending as best he can the old ideas, is frequently made to appear foolish. It has sometimes been asserted that, in his portrayal of Simplicio, Galileo was caricaturing the Pope, or at least that the Pope himself was led to believe so—for which reason the personal friendliness of Urban VIII suddenly ceased, and Galileo was left naked to his enemies.

This, however, is a needless supposition. From their own point of view the ecclesiastical authorities had grounds enough, in the whole tendency of the *Dialogue*, for calling Galileo to account. Sixteen years earlier he had been admonished by the previous Pope, Paul V, and had then promised not to 'hold, teach or defend' the heliocentric theory of Copernicus. Yet in the *Dialogue* this undertaking was patently ignored, the general tenor of the book plainly contradicting what might have been inferred from Galileo's statement in his preface that "it is not from failing to take heed of what others have thought that we have yielded to asserting that the earth is motionless, and holding the contrary to be a mere mathematical caprice."

One cannot but admire the lucidity with which the arguments on each side are marshalled. True, in the discussion, on the fourth and final day, of the causes of the tides, Galileo goes astray, expressing his amazement at Kepler, who "despite his open and acute mind, and though he has at his finger-tips the motions attributed to the earth, has nevertheless lent his ears and assent to the moon's dominion over the waters, to occult properties, and to such puerilities."

For all this, the *Dialogue* must rank as one of the great claims of science, and it is good that such a work should now be available in English and in, moreover, a most lively and readable rendering. Galileo intended it for the layman rather than for the scholar, and the layman can find interest and instruction in it today. E. N. PARKER

The Biochemistry of Genetics

By J. B. S. Haldane (*London, George Allen & Unwin, 1954; 144 pp., 15s.*)

The lectures given by Professor Haldane in the Department of Biochemistry, University College, London, in 1950 and 1952, have now been published as a book. Its style reflects this origin: it makes for easy and stimulating reading, though it could do with more polish. The lectures were addressed mainly to biochemists; there is little doubt that the book will appeal to a much wider audience: biochemists and geneticists, of course, but also everyone who is interested in the advancing frontiers of biology. It is quite intelligible even without a specialised background.

This book is a bird's eye view of the whole of biochemical genetics, a field of biology which tries to give biochemical content to the processes of heredity and variation. Its examples are drawn from all groups of organisms, from unicellular ones to higher animals, including man, and plants. Each of these groups has made its own distinct contributions. One of the valuable features of the book is that it gives a balanced picture of these different approaches. For instance, mainly to work with micro-organisms we owe a clearer statement of the problems of gene-enzyme relationships. To this work we also owe a more balanced approach to the problems of adaptive variation, which up to the very near past were often viewed with irrelevant emotion. On the other hand, from research on inherited metabolic variation in man and on the inheritance of antigenic specificity in man and animals, we have derived the notion that the biochemical uniqueness of the individual is an inevitable consequence of the processes of heredity.

A survey of this kind cannot be, of course, a comprehensive source of detailed factual information. Its value lies in its ability to bring to the surface important connexions between apparently independent features. In this respect the book is exceptionally successful. There is hardly a page in which the reader's interest is not kept alive by the discovery of one of these unsuspected relationships.

In the last chapter—"Tentative conclusions"—this ability to draw the wood in spite of the trees reaches its peak. The whole chapter is a volcano of ideas and suggestions, some of which will certainly have heuristic value. Two of these suggestions the reviewer should like to single out. One is contained in the last sentence of the book ". . . biochemists should attempt to trace the fate of individual molecules and atoms. If they do so they will be brought to recognize that the chemical structure of the chromosome is as detailed as that of a book or a picture, and that the key to a knowledge of that structure is the science of genetics." The other is on an earlier page: ". . . progressive biochemical evolution has not been by making enzymes or genes of a radically new character, but by broadening or narrowing their ranges of specificity, so that one enzyme in an ancestral form would be represented by a battery of enzymes in a descendant . . ."

Whatever the merits, and the faults of detail, of this book, it is certain to stimulate abundant thought, experiments and, perhaps, valuable controversy.

G. PONTECORVO

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